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CONTENTS

Effect of Freezing the Coconut Endosperm on the Extraction of the Oil ..... *Elvira B. Manzanilla* 369

The Blooming and Fruiting Habits of the Ponderosa Chico ... *Leon G. Gonzales and Pablo A. Feliciano, Jr.* 384

Three Methods of Extracting the Fiber of Sansevieria Trifasciata ..... *Bienvenido P. Agpaoa* 399

Control of Buñga ñg Tubo (Aeginetia Indica) with Chemical Weed Killers ..... *Jacinto R. Rivera* 407

Relation of Three Methods of Extracting Kenaf Fibers to Tensile Strength ..... *Severino F. Capulong* 422

Durability of Local Ropes for Tethering Cattle ..... *Valente Villegas* 430

The Horses of North Central Mindanao and Bukidnon ..... *Valente Villegas* 433

College and Alumni Notes 436

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EFFECT OF FREEZING THE COCONUT ENDOSPERM ON THE EXTRACTION OF THE OIL [1]

ELVIRA B. MANZANILLA

WITH THREE TEXT FIGURES

Freezing the grated coconuts preparatory to pressure extraction did not significantly affect the extraction of oil. In some instances, freezing resulted in a lower percentage of oil extraction. The average percentages of oil extraction of the control ranged from 73.05 to 50.60, and those of the frozen samples, from 69.36 to 47.91.

Temperature, rate of freezing, and alternate freezing and thawing did not affect the percentage of extraction of oil. In general, at the same temperature, longer freezing time seemed to reduce the percentage of oil extraction. The probable reasons for this are protein denaturation, curdling of the cream, and evaporation of water.

There are two general commercial methods of obtaining coconut oil: (1) by the copra method in which the coconut is dried and the oil pressed from the copra and (2) by the "gata" method which entails the extraction of the cream from the fresh coconut endosperm and the subsequent breaking of the cream emulsion. Although only about seventy per cent of the total oil goes into the cream ("gata"), the "gata" method is still more advantageous to use because it eliminates the preparation of copra which, if improperly made, gives inferior oil. Moreover, this method permits the recovery of the protein of the coconut and requires comparatively simple, light, and less expensive machinery. It is therefore desirable to develop the process of extracting coconut oil by the "gata" method, and the field of improvement seems to lie in increasing the recovery of the oil.

This study was based on the hypothesis that freezing and thawing tend to break plant cells and tissues. Both plant and animal tissues are known to be punctured by growing ice crystals, and the cell contents to leak out upon thawing. If this should happen to the coconut endosperm, then the cells and tissues could be broken and more oil would be released. As there is no literature on the use of freezing to break the cells of the coconut endosperm to liberate more oil, the present work was conducted from April, 1953, to February, 1954, in the laboratory of the Department of Agricultural Chemistry.

Gortner, Erdman, and Masterman [2] studied the relative value of unfrozen and frozen foods, with special reference to the possible losses of vitamins. Although their work did not cover the changes which may occur in proteins, carbohydrates, minerals, and particularly fats, it indicated that the nutritive value of the frozen constituents is substantially unchanged.

[1] Central Experiment Station Contribution No. 1736. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Agricultural Chemistry under the direction of Associate Professor Julian Banzon.

[2] W. A. Gortner, F. S. Erdman, and N. K. Masterman, "Principles of Food Freezing," John Wiley and Sons, Inc., New York, 1948, 2nd ed., 281 pp.

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Jacobs [3] reported the following:

> From the physiological point of view, the salient feature of freezing appears to be that ice formation occurs mainly in the intercellular space of the tissue. The formation of ice effects a concentration of solutes in the liquid phase surrounding the cells, especially an increase in the hydrogen-ion concentration. This increased concentration disturbs the osmotic equilibrium of the cell, causing the removal of water from the cell contents into the intercellular space to form ice and thus causing death of the cell. Also, a dehydration of the protoplasmic colloids is effected which may cause irreversible changes in structure and function of the cell, in turn reflected in gross effects on tissue quality. This may be traceable to an increase in the viscosity of the protoplasm to a point at which the cell cannot function.
>
> Even though water is present in the tissue in both the free and bound state, there seems to be little difference between the behavior of the two during the freezing process. The changes in the tissues as a result of freezing may be considered analogous to "salting out" of proteins, also a dehydration phenomenon.

Tressler and Evers [4] stated that Woolrich and Bartlett believe that mechanical damage of cellular structure when foods are frozen may be due to growing ice crystals. Reay was reported by Gortner, Erdman, and Masterman [5] as stating that in most cases the proteins are not physically altered or denatured during the freezing process and that any denaturation which does occur does not affect adversely the nutritive value.

MATERIALS AND METHODS

General method of conducting the experiment. Although temperature, time, rate, and method of freezing varied in the different experimcnts, only one general procedure was followed. Mature coconuts harvested from trees over 25 years old were grated and mixed thoroughly to have a homogeneous sample. Thirty-gram portions were placed in 150-ml. beakers. Two portions were used as the control, and the rest were frozen at the desired lengths of time, temperatures, and rates of freezing.

A Kelvinator freezer with a top lid was run to a temperature of −10°C. or −5°C., depending on the kind of test. The temperature was maintained by regulating the size of the opening. The beakers containing the 30-gram portions were then placed in the freezer. Thermometers were inserted into the beakers, with the mercury bulbs covered by the grated coconut endosperm to maintain the temperature. The beakers containing the samples were kept in the freezer for the required number of hours, after which they were removed and then thawed in warm water (about 60°C.) for 30 minutes. Then the samples were pressed separately in the Carver hydraulic press at 4000 psi., and the cream and the residue were separately collected, weighed, and measured. The oil content of the cream was

[3] M. B. Jacobs (ed.), "The Chemistry and Technology of Food and Food Products," Interscience Publishers, Inc., New York, 1944, Vol. 2, 890 pp.

[4] D. K. Tressler and C. F. Evers, "The Freezing Preservation of Foods," The Avi Publishing Company, New York, 1947, 2nd ed., 932 pp.

[5] Gortner, Erdman, and Masterman, *op. cit.*

determined by the Babcock method, with some modifications. The residue was oven-dried and its oil content determined according to the Soxhlet method as described by the Association of Official Agricultural Chemists.[6]

In the test on fast rate of freezing, the beakers containing the samples were immersed in brine solutions kept at the desired temperatures, −5°C. and −10°C. In this study, "slow freezing rate" is taken to mean that the samples reached the required temperature in 25 to 30 minutes; "fast freezing rate," in 10 to 15 minutes.

Two replications with two trials each were made for each treatment and the control.

Modified Babcock procedure. When the prescribed Babcock procedure for cow's milk or cream was used on coconut cream, the layer of oil finally obtained was indistinct. After many trials, satisfactory results were obtained with the Babcock procedure modified by diluting the cream with water. Fifteen ml. of the cream was diluted to 50.00 ml. in a volumetric flask, and 9 ml. of concentrated sulfuric acid was added to a 10-ml. aliquot. The actual oil content of the coconut cream was determined from the new calibration of the Babcock bottle. Recalibration was done by filling the Babcock bottle with distilled water up to the zero mark and measuring the weight of oil needed to fill the marked portion of the bottle. This weight was divided by 100 (corresponding to the number of lines or divisions on the neck of the bottle). The quotient represented the weight of oil to a division of the bottle. The results of the calibration are shown in table A.

TABLE A

ITEM	TRIAL 1	TRIAL 2	TRIAL 3
Volume of oil, milliliters	4.87	4.88	4.88
Weight of oil, grams	4.5048	4.5062	4.5060
Number of Babcock bottle divisions	100	100	100
Weight of oil to a division	0.0450	0.0450	0.0450

Average weight of oil to a division = 0.0450 gram.

Photomicrographs. Photomicrographs of longitudinal and cross sections of the coconut endosperm, both the frozen and the control, were made. The sections, each 40 micra thick, were prepared with the use of a microtome. Drops of Sudan III stain dissolved in alcohol were added to each section to make the oil globules more visible. The samples were examined under the microscope and later photomicrographed (figs. 1 to 3) at 47 times magnification.

Calculation of the percentage of extraction. The percentage of oil extraction was calculated by multiplying the weight of oil in the

[6] H. A. Lepper (ed.), "Official Methods of Analysis of the Association of Official Agricultural Chemists," A.O.A.C., Washington 4, D.C., 1950, 7th ed., 910 pp.

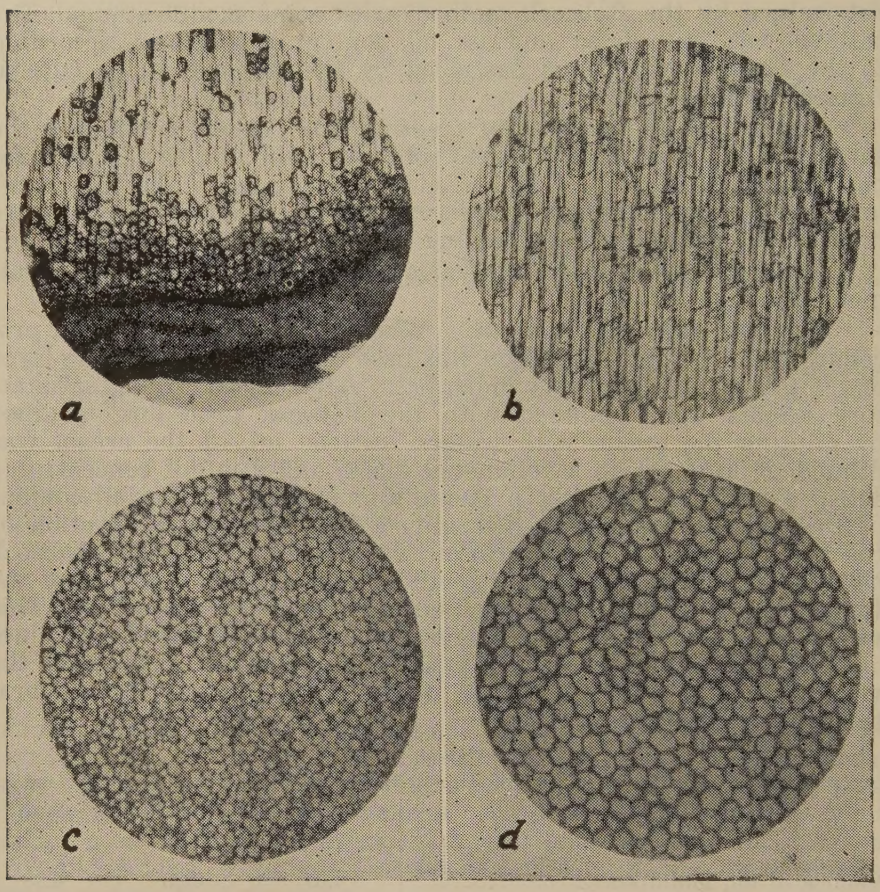

Fig. 1-a. Photomicrograph of longitudinal section of the bottom part of a normal coconut endosperm, showing oil globules (black spots) concentrated toward the rind. (47×). 1-b. Photomicrograph of longitudinal section of the middle part of a normal coconut endosperm, showing oil globules. (47×). 1-c. Photomicrograph of cross section of the bottom part of a normal coconut endosperm, showing oil globules in the cells. (47×). 1-d. Photomicrograph of cross section of the middle part of a normal coconut endosperm, showing oil globules in the cells. (47×).

cream by 100 and then dividing the product by the total weight of oil present. To illustrate, a 30-gram portion was found to contain 8.7837 grams of oil (Soxhlet analysis); a similar 30-gram portion, when pressed in the Carver press, gave cream containing 4.5969 grams of oil (Babcock analysis); therefore, the oil extraction was

$$\frac{4.5969 \times 100}{8.7837} = 52.83 \text{ per cent.}$$

RESULTS AND DISCUSSION

General effect of freezing. Freezing the grated coconut endosperm preparatory to pressure extraction did not seem to increase the percentage of oil extraction. Insignificant differences were obtained at the same temperature, time, and method of freezing (tables 1a, 1c, 2a, and 2c). Although the other replications gave insignificant differences, there seemed to be a tendency for a lower percentage of oil extraction in the samples which received the freezing treatment.

A lower percentage of oil extraction was obtained among the treated samples (table 1a), probably because the water may have evaporated during the freezing and thawing. A similar observation was reported by Ramsbottom and Koonz, as cited by Gortner, Erdman, and Masterman,[7] in their study on the relation of the freezing temperature to the drip of frozen-defrosted beef. They observed that smaller cuts of meat tend to lose more fluid (drip), probably because of the failure of the muscle fibers to absorb the thawed liquid. The oozing of fluid from a thawed coconut endosperm may also be explained by the failure of the tissues to reabsorb the thawed liquid. Because of the loss of this liquid, which is really a form of dehydration, fissures or cracks are found in the endosperm.

Cracks and fissures were observed on the thawed endosperm, but no general break in cell wall was seen (figs. 2c, 2d, 3a, and 3b). Microscopic examination of the frozen tissues showed that freezing split the tissues of the coconut endosperm. The coconut endosperm cells appeared to be tough and resistant to freezing and thawing. Probably there was not enough water to form large crystals of ice to puncture the cell wall since a coconut endosperm contains only 50 per cent water. These explanations of freezing damage are inferred from information on temperate fruits and vegetables whose moisture contents are high, 60 to 90 per cent.

The samples that received the freezing treatments were observed to give curdled cream. A comparison of figure 1a and figures 2b and 2c shows larger oil globules on the thawed endosperm because of coalescence of the small globules into larger ones. The normal emulsified state of the oil was possibly upset because of the denaturation of the protein. According to Reid, as cited by Clayton,[8] the freezing of milk causes clumping of fat globules. Gortner, Erdman, and Masterman (1948) reported that freezing alters the very fine colloidal particles of milk and cream and that under many processing conditions, the insoluble fractions (butterfat and casein) separate on thawing. They said that this separation is due to the phenomenon of "oiling-off" wherein the butterfat separates and rises in flocs by a coalescence of the final fat globules. Jacobs (1944) observed that freezing caused a denaturation of the protoplasmic colloids.

In addition, then, to the physical changes of the oil in the cell during freezing and thawing, the possibility of the denaturation of

[7] Gortner, Erdman, and Masterman, *op. cit.*

[8] W. Clayton, "Colloid Aspects of Food Chemistry and Technology," J. & A. Churchill, Ltd., London, 1932, 2nd ed., 571 pp.

the protein of the grated coconut as a result of freezing and thawing could also be considered. If protein, principally the emulsifying agent in the cream, was made ineffective as an emulsifying agent by denaturation or curdling, then the decrease in oil extraction may be attributed to this cause. Protein denaturation is usually accompanied by changes in the physical state. A sort of lipo-protein formation and/or entrapped oil globules in protein aggregates may occur.

The coconut cream extracted from the frozen samples turned slightly yellowish when left for some time at room temperature.

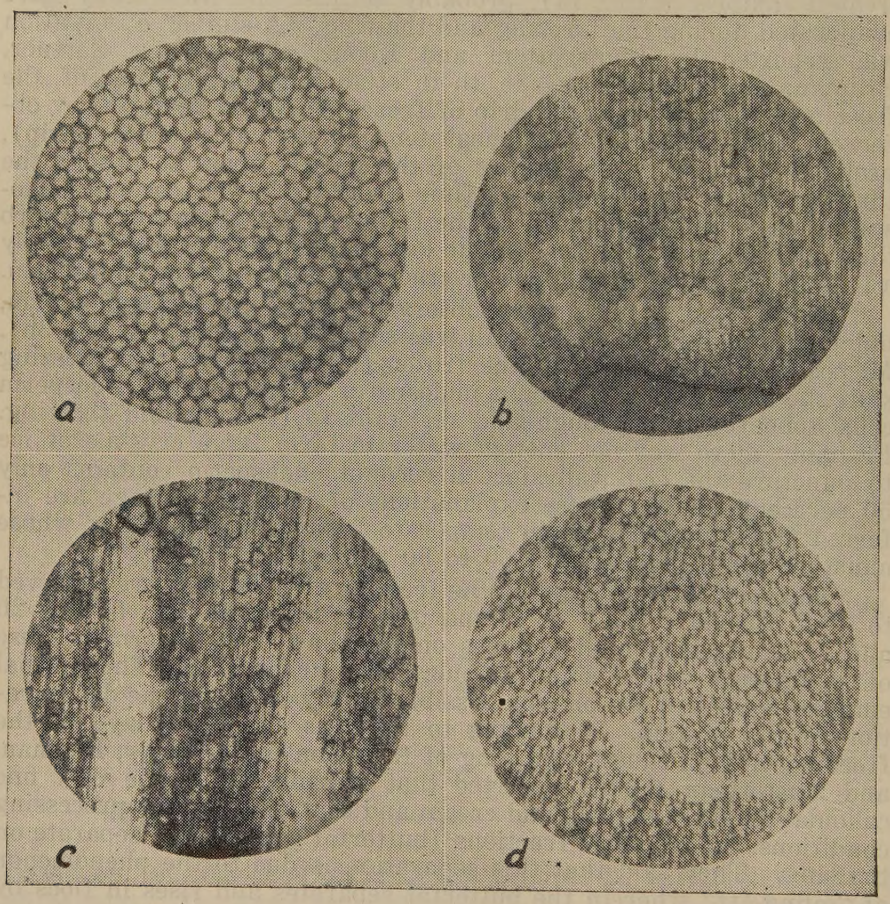

Fig. 2-a. Photomicrograph of cross section of the top portion of a normal coconut endosperm, showing oil globules in the cells. (47×). 2-b. Photomicrograph of longitudinal section of the bottom part of a frozen coconut endosperm, showing the oil globules (black spots) and the shrunken parts of the tissue. (47×). 2-c. Photomicrograph of longitudinal section of the middle part of a frozen coconut endosperm, showing the oil globules and the cracked tissue. (47×). 2-d. Photomicrograph of cross section of the bottom part of a frozen coconut endosperm, showing oil globules inside the cells and the cracked tissue. (47×).

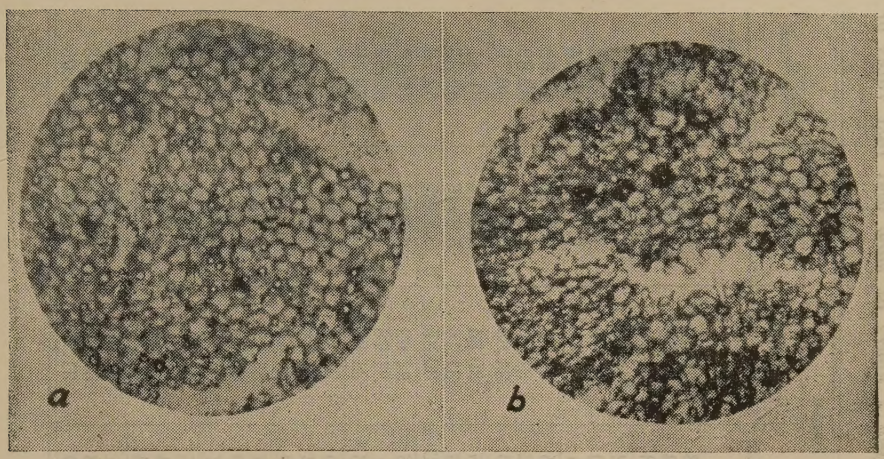

Fig. 3-a. Photomicrograph of cross section of the bottom part of a frozen coconut endosperm, showing the oil globules and the cracked tissue. (47×). 3-b. Photomicrograph of cross section of the top part of a frozen coconut endosperm, showing the cracked tissue. (47×).

This observation may be in accordance with the finding of Joslyn, as cited by Gortner, Erdman, and Masterman (1948), who attributes the browning of most frozen fruits to the formation of pigmented substances from the decomposition of certain chemical constituents and the reaction between some of the constituents of the fruit tissues and the oxygen of the air.

Effect of freezing temperature. For the same time, rate, and method of freezing, varied results were obtained (tables 1b, 1d, 2b, and 2d). If the foregoing explanations for a lower percentage of extraction are valid, then a low temperature would be expected to affect adversely expression of the oil. Perhaps the difference in the temperature (−5° and −10°C.) was not enough to cause a pronounced effect.

Effect of freezing time. In general, at the same temperature, rate, and method of freezing, a longer freezing time tended to decrease the percentage of oil extraction (tables 1b and 1d). This could be taken as evidence to support the explanation of the effect of changes in the emulsified state of frozen oil on the percentage of oil extraction. Increasing the time of freezing must have resulted in a greater denaturation of the proteins.

Effect of freezing rate. There seemed to be no change in the percentage of oil extraction as a result of freezing at slow and fast rates. The time factor in the attainment of the samples of the freezing temperature does not affect the probable causes for the low percentage of oil extraction which have been discussed.

Effect of alternate freezing and thawing. Alternate freezing and thawing had no effect on the percentage of oil extraction. Insignificant results were obtained (tables 2b and 2d).

TABLE 1a

Oil recoveries of the control and the samples frozen at −5° and −10°C. for 2 and 4 hours at slow and fast rates of freezing [a]

EXPERIMENTAL CONDITIONS		TRIAL	RESIDUE		CREAM				OIL EXTRACTION
Temperature	Hours of freezing		Oven-dried weight	Oil content	Volume	Weight	Oil content	Weight of oil	
I [b]			*grams*	*per cent*	*ml.*	*grams*	*per cent*	*grams*	*per cent*
−5°C.	2	1	6.2846	32.66	21.68	19.7548	29.63	5.8536	68.20
		2	7.9745	36.30	19.46	17.4098	31.85	5.5461	64.61
		Average	7.1295	34.48	20.57	18.5823	30.74	5.6998	66.40
	4	1	7.0333	36.19	20.08	19.1202	29.93	5.7228	66.67
		2	7.5154	32.39	19.22	17.5100	31.28	.54777	63.82
		Average	7.2743	34.29	19.65	18.3151	30.60	5.6002	65.24
−10°C.	2	1	6.5585	30.90	21.27	19.1685	31.62	6.0619	70.62
		2	7.7706	33.99	18.94	17.0242	31.70	5.3979	62.89
		Average	7.1645	32.44	20.10	18.0963	31.66	5.7299	66.75
	4	1	6.9863	34.08	19.52	17.2526	30.54	5.2704	61.41
		2	8.1899	33.65	19.98	17.3096	31.16	5.3946	62.85
		Average	7.5881	33.86	19.75	17.2811	30.85	5.3325	62.13
II [c]	2	1	6.2519	34.11	21.43	19.6856	31.02	6.1075	71.16
		2	6.9373	34.96	20.35	18.2601	31.76	5.7997	67.57
		Average	6.5946	34.53	20.89	18.9728	31.39	5.9536	69.36
−5°C.	4	1	7.8028	37.02	20.12	18.0356	28.44	5.1306	59.77
		2	8.7411	35.76	18.59	17.0004	31.16	5.2981	61.72
		Average	8.2719	36.39	19.35	17.5180	29.18	5.2143	60.74
−10°C.	2	1	7.2651	36.09	20.38	18.3134	31.71	5.8083	67.67
		2	7.0781	36.32	20.62	18.3600	32.01	5.8767	68.47
		Average	7.1716	36.20	20.50	18.3367	31.86	5.8425	68.07
	4	1	6.4894	37.92	21.37	19.1685	30.10	5.7699	67.22
		2	7.1948	38.01	19.94	17.7864	30.27	5.3838	62.72
		Average	6.8421	37.96	20.65	18.4774	30.18	5.5768	64.97
Control		1	6.0661	30.08	21.89	19.0431	32.76	6.2386	72.68
		2	6.1454	33.82	22.08	20.4548	30.76	6.2928	73.43
		Average	6.4761	31.95	21.98	19.7489	31.76	6.2657	73.05

[a] Weight of samples, 30.00 grams; moisture content, 52.96 per cent.
[b] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[c] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.

TABLE 1b

Percentage of oil extraction

TOTAL	CONTROL	FROZEN								TOTAL
		I [a]				II [b]				
		—5°C.		—10°C.		—5°C.		—10°C.		
		2 hrs.	4 hrs.	2 hrs.	4 hrs.	2 hrs.	4 hrs.	2 hrs.	4 hrs.	
I	72.68	68.20	66.67	70.62	61.41	71.16	59.77	67.67	67.22	605.40
II	73.43	64.61	63.82	62.89	62.85	67.57	61.72	68.47	62.72	588.08
Total	146.11	132.81	130.49	133.51	124.26	138.73	121.49	136.14	129.94	1,193.48
Mean	73.05	66.40	65.24	66.75	62.13	69.36	60.74	68.07	64.97	

[a] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[b] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.

Analysis of variance

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARES	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Treatments	8	219.0078	27.3759	4.0731	3.23	5.47
Determinations within treatment	9	60.4901	6.7211			
Total	17	279.4979				

L.S.M.D. = 5.8586

TABLE 1c

Oil recoveries of the control and the samples frozen at −5° and −10°C. for 2 and 4 hours at slow and fast rates of freezing [a]

EXPERIMENTAL CONDITIONS		TRIAL	RESIDUE		CREAM				OIL EXTRACTION
Temperature	Hours of freezing		Oven-dried weight	Oil content	Volume	Weight	Oil content	Weight of oil	
			grams	*per cent*	*ml.*	*grams*	*per cent*	*grams*	*per cent*
I [b]	2	1	5.2092	31.69	21.24	20.3904	21.87	4.4604	50.78
−5°C.		2	5.4836	32.12	20.68	19.8487	21.87	4.3438	49.44
		Average	5.3464	31.90	20.96	20.1195	21.87	4.4016	50.11
	4	1	5.8204	34.77	20.76	19.7494	22.07	4.3596	49.63
		2	5.3098	30.00	20.98	19.9016	20.55	4.0911	46.57
		Average	5.5651	32.38	20.87	19.8255	21.31	4.2253	48.18
−10°C.	2	1	5.4520	30.75	20.54	19.7636	21.82	4.3134	49.10
		2	6.1647	30.87	20.12	18.9288	22.32	4.2252	48.10
		Average	5.8083	30.81	20.33	19.3462	22.07	4.2693	48.60
	4	1	5.6925	32.70	18.79	17.8712	22.07	3.9459	44.92
		2	4.9221	35.75	20.11	19.2091	21.98	4.2231	48.07
		Average	5.3073	34.22	19.45	18.5401	22.02	4.0845	46.49
II [c]	2	1	4.3946	31.74	20.12	21.2816	20.27	4.3134	49.10
−5°C.		2	4.1704	29.92	20.52	19.6623	21.91	4.3092	49.05
		Average	4.2825	30.83	21.32	20.4719	21.09	4.3113	49.07
	4	1	5.0595	32.43	20.34	18.9793	20.89	4.9663	56.53
		2	5.0899	31.76	19.98	17.7682	23.61	3.5964	40.94
		Average	5.0747	32.05	20.16	18.3737	22.25	4.2813	48.73
−10°C.	2	1	5.6354	32.69	20.08	18.9214	22.28	4.2168	48.00
		2	6.2001	32.83	20.92	19.9995	21.96	4.3932	50.01
		Average	5.9177	32.76	20.50	19.4604	22.12	4.3050	49.00
	4	1	5.6967	27.13	18.68	17.5198	22.39	3.9228	44.65
		2	4.6316	32.05	20.02	19.3493	21.78	4.2042	47.86
		Average	5.1641	29.59	19.35	18.4345	22.08	4.0635	46.25
Control		1	5.3233	30.13	21.89	20.8524	22.04	4.5969	52.83
		2	5.1816	29.32	22.82	20.9366	20.51	5.2939	48.88
		Average	5.2524	29.72	21.95	20.8945	21.27	4.4908	50.60

[a] Weight of samples, 30.00 grams; moisture content, 52.96 per cent.
[b] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[c] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.

TABLE 1d

Percentage of oil extraction

TOTAL	CONTROL	FROZEN								TOTAL
		I [a]				II [b]				
		—5°C.		—10°C.		—5°C.		—10°C.		
		2 hrs.	4 hrs.	2 hrs.	4 hrs.	2 hrs.	4 hrs.	2 hrs.	4 hrs.	
I	52.83	50.78	49.63	49.10	44.92	49.10	56.53	48.00	44.65	445.54
II	48.88	49.44	46.57	48.10	48.07	49.05	40.94	50.01	47.86	428.92
Total	101.71	100.22	96.20	97.20	92.99	98.15	97.47	98.01	92.51	874.46
Mean	50.60	50.11	48.18	48.60	46.49	49.07	4.873	49.00	46.25	

[a] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[b] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.

Analysis of variance

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARES	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Treatments	8	35.8997	4.4875	0.2737	3.23	5.47
Determinations within treatment	9	147.5608	16.3956			
Total	17	183.4605				

TABLE 2a

Oil recoveries of the control and the samples frozen at −5° and −10°C. for 1 × 1 hours (samples were frozen for 1 hour, thawed, refrozen for another hour, and then thawed again) at slow and fast rates of freezing [a]

EXPERIMENTAL CONDITION	TRIAL	RESIDUE		CREAM				OIL EXTRACTION
Temperature		Oven-dried weight	Oil content	Volume	Weight	Oil content	Weight of oil	
		grams	*per cent*	*ml.*	*grams*	*per cent*	*grams*	*per cent*
Control	1	7.1814	33.45	18.28	16.9638	24.24	4.1130	51.94
	2	7.2293	32.16	12.22	16.8714	24.30	4.0995	51.77
	Average	7.2050	32.80	18.25	16.9176	24.27	4.1062	51.85
I [b] −5°C.	1	7.5009	31.11	18.11	16.8441	24.19	4.0747	51.45
	2	7.4764	35.81	17.89	16.5338	24.34	4.0254	51.46
	Average	7.4886	33.46	18.00	16.6889	24.26	4.0499	51.45
−10°C.	1	7.3811	34.08	18.26	17.0200	24.14	4.1085	51.88
	2	7.6586	33.32	18.19	17.0986	23.93	4.0927	51.68
	Average	7.5188	33.70	18.22	17.0593	24.03	4.1006	51.78
II [c] −5°C.	1	8.1654	31.21	17.54	16.9664	22.74	3.6834	46.51
	2	7.3826	32.75	18.08	16.6390	24.45	4.0680	51.30
	Average	7.7741	31.98	17.81	16.4177	23.59	3.8757	48.94
−10°C.	1	7.4994	31.86	17.99	16.8062	24.08	4.0477	51.11
	2	7.6148	31.00	17.92	16.9105	23.84	4.0320	50.91
	Average	7.5571	31.43	17.95	16.8583	23.96	4.0398	51.01

[a] Weight of sample, 30.00 grams; moisture content, 49.29 per cent.
[b] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[c] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.

TABLE 2b

Percentage of oil extraction

TOTAL	CONTROL	FROZEN				TOTAL
		I [a]		II [b]		
		—5°C. 1 × 1 hrs.[c]	—10°C. 1 × 1 hrs.[c]	—5°C. 1 × 1 hrs.[c]	—10°C. 1 × 1 hrs.[c]	
I	51.94	51.45	51.88	46.51	51.11	252.89
II	51.77	51.46	51.68	51.37	50.91	257.19
Total	103.71	102.91	103.56	97.88	102.02	510.08
Mean	51.85	51.45	51.78	48.94	51.01	

[a] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[b] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.
[c] Samples were frozen for 1 hour, thawed, refrozen for another hour, and then thawed again.

Analysis of variance

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARES	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Treatments	4	11.5797	2.8949	0.6620	5.19	11.39
Determinations within treatment	5	21.8643	4.3728			
Total	9	33.4440				

TABLE 2c

Oil recoveries of the control and the samples frozen at −5° and −10°C. for 1 × 1 hours (samples were frozen for 1 hour, thawed, refrozen for another hour, and then thawed again) at slow and fast rates of freezing [a]

EXPERIMENTAL CONDITION	TRIAL	RESIDUE		CREAM				OIL EXTRACTION
Temperature		Oven-dried weight	Oil content	Volume	Weight	Oil content	Weight of oil	
		grams	*per cent*	*ml.*	*grams*	*per cent*	*grams*	*per cent*
Control	1	5.3233	30.13	21.89	20.8524	22.04	4.5969	52.83
	2	5.1816	29.82	20.82	20.9366	20.51	4.2939	48.88
	Average	5.2524	29.72	21.95	20.8945	21.27	4.4908	50.60
I [b] −5°C.	1	5.9368	28.48	19.86	18.9286	22.03	4.1706	47.48
	2	4.6879	30.17	21.09	20.0418	22.10	4.4289	50.42
	Average	5.3123	29.32	20.47	19.4852	22.06	4.2997	48.95
−10°C.	1	5.0623	30.94	20.74	19.4666	22.27	4.3554	49.58
	2	4.9642	32.03	21.55	20.4574	20.54	4.5255	51.52
	Average	5.0132	31.48	21.14	19.9620	21.45	4.4404	50.55
II [c] −5°C.	1	4.9536	34.76	21.75	21.1758	21.56	4.5675	51.99
	2	5.4746	32.98	21.46	19.5843	23.01	4.5066	51.30
	Average	5.2126	33.87	21.60	20.3800	22.28	4.5370	51.64
−10°C.	1	5.2584	30.58	20.44	19.4221	20.52	3.9858	45.37
	2	4.7642	31.96	21.11	19.7547	22.44	4.4331	50.46
	Average	5.0113	31.22	20.77	19.5884	21.48	4.2094	47.91

[a] Weight of sample, 30.00 grams; moisture content, 57.23 per cent.
[b] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[c] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.

TABLE 2d

Percentage of oil extraction

TOTAL	CONTROL	FROZEN				TOTAL
		I [a]		I [b]		
		—5°C. 1 × 1 hrs. [c]	—10°C. 1 × 1 hrs. [c]	—5°C. 1 × 1 hrs. [c]	—10°C. 1 × 1 hrs. [c]	
I	52.83	47.48	49.58	51.99	45.37	247.25
II	48.88	50.42	51.52	51.30	50.46	262.58
Total	101.71	97.90	101.10	105.29	95.83	499.83
Mean	50.60	48.95	50.55	51.64	47.91	

[a] Slow freezing rate—desired temperature is attained in 25 to 30 minutes.
[b] Fast freezing rate—desired temperature is attained in 10 to 15 minutes.
[c] Samples were frozen for 1 hour, thawed, refrozen for another hour, and then thawed again.

Analysis of variance

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARES	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Treatments	4	18.3756	4.5939	0.8446	5.19	11.39
Determinations within treatment	5	27.1970	5.4394			
Total	9	45.5726				

THE BLOOMING AND FRUITING HABITS OF THE PONDEROSA CHICO [1]

LEON G. GONZALEZ AND PABLO A. FELICIANO, Jr.

WITH TWO TEXT FIGURES

The flowers of Ponderosa begin to open at about three o'clock in the afternoon; they are fully open by 1:00 o'clock the following morning. On the fourth day of emergence of the pistil from the corolla, the stigma becomes receptive from 8:00 a.m. to 5:00 p.m. If pollination is unsuccessful the flower turns brown and falls off in seven days; if successful, enlargement of the ovary is observed in two weeks after pollination. The fruit matures in about 8.5 months.

Of the natural and artificial methods of pollination used, pollination by hand was the most effective. The least effective was open-pollination after emasculation. The pollen of native chico induced more fruit set on Ponderosa flowers than that of "Sawoe" Manila and "Java" chico. The insect pollinating agents of the Ponderosa and native chico were *Hermetia* sp., *Oecaphylla smaragdina* Fabr., and *Dolichoderus bituberculatus* Mayr.

The productivity of a Ponderosa tree seems to be influenced by fertility of the soil, drainage, presence of weeds, exposure to sunlight, protection from high winds, and nearness to native chico trees. Vigorous trees give a high percentage of fruit set. The insect which inflicted serious damage on the flowers of Ponderosa and native chico trees was a moth of the family Gelechiidae. The unproductiveness of the Ponderosa chico cannot altogether be attributed to faulty pollination alone. The damage wrought by insect pests deserves serious consideration.

The Ponderosa chico has attained considerable popularity in the Philippines since its introduction in 1912 from the Botanic Gardens at Buitenzorg, Java.[2] The unusually large size, fine texture, juiciness, taste, and suitability for drying purposes of the fruit make it well adapted for commerce. The tree seems to have one drawback—it is a rather shy bearer.[3] The opinion of many growers on the subject, however, is divided; some assert the erratic fruiting habit of the plant and others hold the opposite view.

In the hope of shedding some light on the controversy, an investigation was conducted to study the blooming and fruiting habits of the Ponderosa chico and to determine the cross-compatibility of the Ponderosa with other forms of chico. The work was done from December, 1951, to September, 1952, in the orchard of the College of Agriculture, Los Baños, Laguna, at the Exconde citrus orchard [4]

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[1] Central Experiment Station Contribution No. 1737. Thesis presented for graduation, October, 1952, with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Agronomy under the direction of the senior author.

[2] L. G. Gonzalez, *Philippine Agriculturist,* **20**, 604 (1932).

[3] P. A. Rodrigo, *Agric. Indus. Monthly,* [2] **6**, 3 (1938).

[4] The writers are indebted to Mr. Gil Exconde for the many courtesies shown them.

in Lamot, Calauan, Laguna, and in private backyards in Los Baños and Biñan, Laguna; Mandaluyong, Rizal; Sibul Springs, Bulacan; and Apalit, Pampanga.

MATERIALS AND METHODS

A total of 77 trees was used in this study: 44 marcotted Ponderosa trees, the original Ponderosa tree, 30 native trees, one "Sawoe" Manila, and one "Java" seedling tree. A brief description of each Ponderosa tree is given in table 1.

So that self-pollination would be avoided, flowers were usually emasculated in the afternoon prior to anther dehiscence the following morning. In chico flowers, dehiscence occurs three days after the stigma has come out of the corolla. Emasculation was performed with a pair of pointed forceps after the corolla had been split. Each flower cluster was labeled and bagged.

Four methods of pollination were used. In open-pollination, the flowers did not receive any treatment; the flower clusters were merely tagged for identification. Natural self-pollination, the second method, was insured by preventing outside pollen from pollinating the stigmas. The flower clusters were bagged a day before the stigmas emerged from the corollas; 10 days after, the bags were removed. In artificial self-pollination the flowers were bagged five days before pollination. At the time of receptivity of the stigmas, the pollen grains were transferred to the stigmas of the emasculated flowers in the same cluster. The fourth method was emasculation before exposure to open-pollination. The flowers were emasculated in the afternoon prior to dehiscence. They were exposed to open-pollination the following morning.

RESULTS AND DISCUSSION

Floral structure of Ponderosa

The flower structure of the Ponderosa variety is similar to that of *Achras zapota* Linn. as described in Merrill's *Flora de Manila*. There are at least two differences, however. The pistil of the native chico (fig. 1) is shorter and closer to the anthers, a condition which renders self-pollination possible. Then, all the anthers of the native chico develop normally, but in the Ponderosa, only one or two reach maturity.

Blooming and fruiting habits of Ponderosa

Emergence and opening of flowers. The length of time from emergence of flower bud at the leaf axil to full opening of the flower ranged from 47 to 58 days, or an average of 51.8 days (table 2). The flowers began to open at 3:00 o'clock in the afternoon; they were fully open by 1:00 o'clock the following morning. Pollinated and unpollinated flowers closed 72 hours after opening.

Order of blooming. The lowermost flowers at the base of the cluster, being the oldest, opened first. Blooming continued upwards, and the latest flower bud to emerge opened last. The length of time a cluster bloomed depended on the size of the cluster—the larger the flower cluster the longer was the blooming period. An average-sized cluster bloomed in about six days.

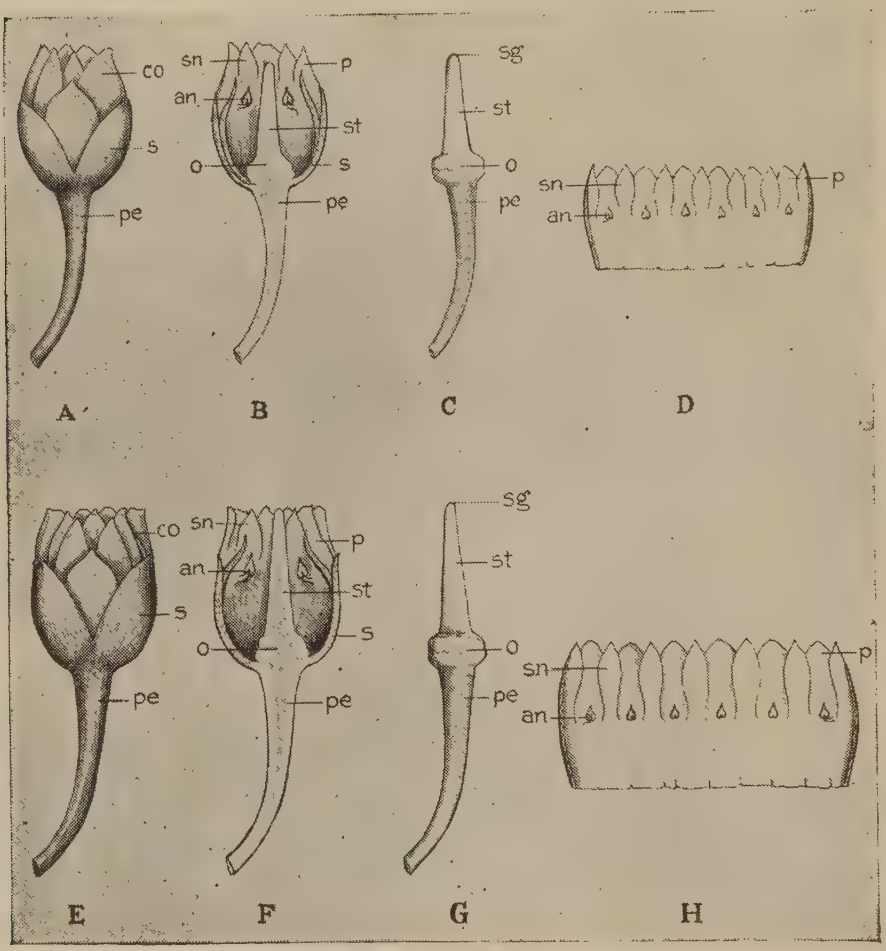

Fig. 1.—Difference in structural details between the Ponderosa and native chico flowers. Upper row: A. opened flower of native chico; B. longitudinal section; C. pistillate flower; D. unfolded corolla. Lower row: E. opened flower of Ponderosa chico; F. longitudinal section; G. pistillate flower; E. unfolded corolla. *Co*, corolla; *s*, sepals; *pe*, peduncle; *sn*, staminodes; *p*, petal; *an*, anther; *sg*, stigma; *st*, style; *o*, ovary. (*Photographed by the Photographic Division.*)

Anther dehiscence. Anther dehiscence of the flowers of Ponderosa was difficult to note because very few flowers with one or two normal anthers could be found. Even in normal anthers dehiscence could hardly be observed, for pollen grains were very few and were lumped together. Under such conditions self-pollination and pollen dispersal were difficult to accomplish. With native chico, dehiscence was readily observed because the released pollen grains were scattered all around the style.

Unlike the pollen grains of the native chico which appear black and plump under the low power objective of a compound microscope (fig. 2, left), the pollen grains of Ponderosa are small, transparent,

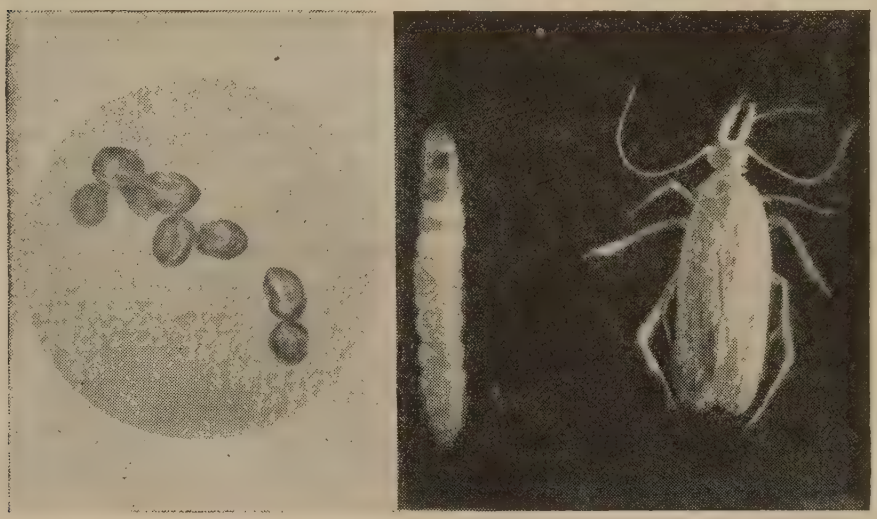

Fig. 2a.—Pollen grains of native chico, × 677. b.—Larvae and adult of the Gelechiidae moth, × 9.2. (*Photographed by the Photographic Division.*)

odd in shape, and all lumped together. Rodrigo [5] found that most of the flowers of Ponderosa have only a few imperfectly developed pollen grains.

Time and duration of receptivity of the stigma. The time of receptivity of the stigma could be judged by its color and condition. The white stigma became dark brown and well covered with a white mucilaginous secretion. Inasmuch as self-pollination is not successful in the Ponderosa flower, the time and duration of receptivity of its stigma were determined by cross-pollination with the native chico. On the fourth day of emergence of the pistil from the corolla, the stigma was receptive from 8:00 o'clock in the morning to 5:00 o'clock in the afternoon. The flowers set fruit when they were pollinated from 8:00 a.m. to 5:00 p.m. (table 10). No flowers set

[5] Rodrigo, *op. cit.*

fruit when they were pollinated between 12:00 noon and 2:30 p.m. Fortunately, however, the period of receptivity of the stigma of the Ponderosa coincided with the period of anther dehiscence of the native chico, thus making cross-pollination possible. The anthers of native chico started to dehisce 38 hours before the flower had fully opened. The flower commenced opening at about two o'clock in the afternoon; it was fully open at about twelve o'clock midnight.

Fruit formation. When pollination was unsuccessful, the flower turned brown and fell off in seven days; but when pollination was successful, the ovary enlarged in two weeks after pollination. In about a month the brown fruit, about the size of a coffee berry, was formed. By that time only the calyx remained intact at the base of the fruit, and the pistil which was like a spine remained at the tip. The fruit matured in about 8.5 months.

Fruit set of Ponderosa under different methods of pollination. The flowers of Ponderosa could not be self-pollinated (tables 3 and 6), and the native chico flowers could not be induced to set fruit with Ponderosa pollen (table 7). The unfertility could be due to poor development of the pollen grains of Ponderosa. The pollen grains, which are smaller than those of the native chico, had to be teased out of the anther because the latter does not dehisce normally. The pollen grains are lumped together, making dispersal difficult.

Unlike those of the Ponderosa, the pollen grains of the native chico are fertile. Table 4 shows that the average fruit set of the native chico when the flowers were naturally self-pollinated was 10.60 per cent, and when they were self-pollinated by hand, 39.60 per cent. The pollen grains of the native chico are plump and dark (fig. 2, left). They could induce fruit set in Ponderosa flowers (table 5). The six anthers of the native chico flower are fully developed and dehisce normally.

Although the pollen grains of the Ponderosa are nonfunctional, the ovules are cross-fertile. The flowers set fruit when they were hand-pollinated with the pollen of the native chico, "Sawoe" Manila, and "Java" chico (table 6). The average percentage of fruit set of five different trees of Ponderosa, when pollinated with native chico, was 30.67 per cent (table 5). It compares favorably with the average fruit set of native chico, which was 39.60 per cent when the flowers were self-pollinated artificially (table 4).

Efficiency of different methods of pollination. Judged by the fruit set (table 4) of native chico trees which were all pollinated in April, 1952, the best method was artificial pollination by hand, which gave 39.60 per cent fruit set. The least efficient method was open-pollination after emasculation of the flower. The low fruit set of this method may be due to the injury to the pistillate flowers during emasculation.

Efficiency of the pollen of different varieties of chico. The native chico induced more fruit set on Ponderosa flowers than "Sawoe"

Manila and "Java" chico. The percentage of fruit set induced by the pollen of the native chico was 40 per cent, which was comparatively higher than the fruit set induced by the pollen of the other varieties of chico.

Variability in fruit set of Ponderosa trees. There was considerable variability in fruit set of the different Ponderosa trees. Tree number T-6A, which was the most vigorous of them all, gave the highest fruit set of 35.56 per cent (table 5). There seemed to be a relation between vegetative vigor and number of flowers formed and number of fruits set. Because of poor soil, tree No. 2, which was the least vigorous of them all, gave the lowest percentage of fruit set, 26.67.

Insect pest of flowers of chico. The insect pest which inflicted serious damage on the flowers of both the Ponderosa and the native chico was a moth of the family Gelechiidae [6] (fig. 2, right). The larvae of this moth fed on the floral organs of the flowers, especially the ovary and the pistillate parts. This pest was prevalent during the months of April, May, and June. The extent of the damage on the native chico flowers ranged from 57.55 to 75.29 per cent (table 8). The damage on the flowers of Ponderosa was at its peak in May (table 9). During the months when this pest was prevalent hardly any fruit was set.

After studying the destructiveness of the gelechiid moth, the writers believe that the unproductiveness of the Ponderosa chico cannot altogether be attributed to faulty pollination alone. The damage wrought by the pest deserves serious consideration.

Insect pollinators. In May, June, and July the insect most commonly found visiting the flowers of Ponderosa and native chico in great numbers was *Hermetia* sp.[7] The other insects found frequenting the flowers were *Oecaphylla smaragdina Fabr.* and *Dolichoderus bituberculatus* Mayr.[8]

Response to fertilizers. Dr. Dioscoro Umali's Ponderosa tree in Biñan, Laguna, which was planted in a hole carefully prepared to insure not only good drainage but also better texture and nutrient content of soil and which was given more than the usual care, did not set fruit despite continuous flowering for over ten years. Since it was planted close to bearing native chicos, lack of pollination could not have been the limiting factor. After the addition of decomposed duck manure to the surrounding soil, the tree improved markedly in vegetative growth, formed healthier flowers, and finally bore fruits within one year. Thereafter, the tree has borne fruits regularly and heavily.

In Mr. Gil Exconde's orchard in Lamot, Calauan, Laguna, it was generally observed that the addition of one-half to one kilo of com-

[6] Identified by Dr. S. M. Cendaña of the Department of Entomology.
[7] Identified by Miss Clare Baltazar of the Department of Entomology.
[8] Identified by Dr. S. M. Cendaña.

plete commercial fertilizer to Ponderosa trees which flowered but did not set fruit rendered them productive.

Response to improvement in drainage. Some of the less productive of Mr. Exconde's trees improved considerably after the drainage around them was improved. Undrained trees had smaller, pale, somewhat mottled leaves and smaller flowers. They bore fruits only occasionally; some remained entirely barren. Timely watering, particularly during the dry season, also had a favorable effect.

Influence of weeds. In the chico orchard of the College, control of the thick growth of cogon around the trees induced the trees to become more fruitful. Thus, weeds can also be a limiting factor.

Influence of increased exposure to sunlight. Some of the trees in Mr. Exconde's orchard now bearing rather heavily were influenced favorably by better exposure to the sun. Those densely shaded by lanzones and citrus trees had the tendency to grow lanky and unhealthy and to bear only few fruits.

Response to protection from high winds. In May, 1952, the writers found a heavily laden Ponderosa tree, over fifteen years old, in the Kawilihan Estate owned by Mr. Jorge Vargas in Mandaluyong, Rizal. According to the gardener, the tree has consistently been a good bearer for the last five years. It grows close to an adobe wall about ten feet high, which acts as a good windbreak. This suggests that protection from high winds can induce heavy fruit set in Ponderosa. The tree does not seem to have had any extraordinary care except for constant watering in dry weather.

Influence of marcotting. In general, well-rooted marcots flowered continuously from the time they were severed from the main tree. Only a few of the marcots, however, set fruit readily. Most of the flowers were small and not well formed. In their fourth year, trees properly cared for bore big flowers and were very fruitful. One grafted Ponderosa tree in the nursery fruited heavily two years after topworking.

Influence of nearness to native trees. In general, vigorously growing Ponderosa trees planted close to native chico trees bear regularly and heavily. Dr. Valeriano C. Calma's Ponderosa trees are a good example of this. An unhealthy Ponderosa, however, is not productive even if it is planted close to a native chico tree. A sickly looking tree of Mr. Gana of Biñan, Laguna, which is just six meters away from a bearing native chico tree, has not produced any fruit for the last 14 years. Instances are known of Ponderosa trees which grow close to native chico becoming productive only after manuring and fertilization.

TABLE 1

Description of Ponderosa trees used in the study

TREE NUMBER [a]	AGE	SIZE (HEIGHT × CROWN)	DISTANCE TO NEAREST BEARING NATIVE CHICO	FRUITING PERFORMANCE
	years		*meters*	
T–1	5–7	3 × 3½	11	Irregular light bearer
T–2	5–7	4 × 5	6	Moderate irregular bearer
T–3	5–7	4 × 5	6	Moderate irregular bearer
T–4	5–7	2 × 1½	6	Barren
T–5	5–7	2½ × 2	6	Barren
T–6	5–7	4 × 5	6	Irregular heavy bearer
T–7	4–7	2½ × 3	6	Irregular light bearer
T–8	4–7	3½ × 3	6	Regular heavy bearer
T–9	12	5½ × 4½	6	Regular heavy bearer
T–10	10	5 × 5	6	Irregular shy bearer
T–11	6	6 × 7	50	Irregular light bearer
T–12	10	7 × 7	85	Regular moderate bearer
T–13	8	6½ × 6	50	Regular heavy bearer
T–14	8	7½ × 5	85	Regular moderate bearer
T–15	10	7½ × 6	75	Regular moderate bearer
T–16	8	6 × 4½	76	Regular moderate bearer
T–17	10	6 × 5½	70	Regular moderate bearer
T–18	10	7 × 6	70	Regular heavy bearer
T–19	5	6½ × 5	10	Regular heavy bearer
T–20	7	6 × 5	80	Regular moderate bearer
T–21	7	6 × 5	90	Irregular moderate bearer
T–22	8	7 × 5½	50	Irregular moderate bearer
T–23	8	9 × 6	40	Regular heavy bearer
T–24	8	6½ × 5	13	Regular heavy bearer
T–25	12	9½ × 10	13	Regular heavy bearer
T–26	9	2 × 6	30	Irregular light bearer
T–27	9	8 × 6½	45	Irregular heavy bearer
T–28	9	7 × 5½	40	Irregular heavy bearer
T–29	9	7 × 5	45	Irregular light bearer
T–30	9	7½ × 5	50	Irregular moderate bearer
T–31	13	Full-grown	Planted with native trees	Unusually heavy bearer
T–32	12	Full-grown	Far from native trees	Regular heavy bearer
T–33	12	Full-grown	Near native trees	Exceptionally heavy bearer
T–34	15	5½ × 5	5	Regular moderate bearer
T–35	10	4 × 3½	10	Regular heavy bearer
T–36	12	6 × 5	10	Regular moderate bearer
T–37	10	5 × 4	8	Irregular light bearer
T–38 [b]	40	8 × 6	20	Regular moderate bearer
T–39	18	8 × 7	16	Regular moderate bearer
T–40	12	Full-grown	Far from native trees	Regular heavy bearer
T–41	14	4 × 3	2	Never fruited
T–42	12	6 × 5	15	Bore heavily after application of duck manure
T–43	6	4½ × 4	35	Irregular heavy bearer
T–44	4	3½ × 3	9	Irregular light bearer
T–45	5	4 × 5	6	Regular light bearer

[a] T-1 to T-10 are trees in the College orchard; T-11 to T-20 are owned by Mr. G. Exconde of Lamot, Calauan, Laguna; T-31, owned by Dr. Bienvenido M. Gonzalez of Apalit, Pampanga; T-32, owned by Mr. Flavio Gonzalez of Sibul Springs, Bulacan; T-33, owned by Dr. Valeriano C. Calma of College, Laguna; T-35, owned by Mr. Aurelio Almazan of Lalacay, Los Baños, Laguna; T-36 and T-37, owned by Mr. Felipe Lopez of College, Laguna; T-38 and T-39, owned by Mr. Silvio Lopez of College, Laguna; T-40, owned by Mr. Jorge Vargas of Mandaluyong, Rizal; T-41, owned by Mr. F. O. Gana of Biñan, Laguna; T-42, owned by Dr. D. L. Umali; and T-43 to T-45, owned by Dr. Leon G. Gonzalez of College, Laguna.

[b] All the trees were propagated by marcottage except T-38, which was the original seedling variety.

TABLE 2

Number of days from emergence of Ponderosa flower buds to flower opening [a]

FLOWER NUMBER	DATE OF EMERGENCE OF FLOWER BUD	DATE OF OPENING	NUMBER OF DAYS FROM EMERGENCE TO OPENING
1	February 23, 1952	April 15, 1952	52
2	February 23, 1952	April 15, 1952	52
3	February 23, 1952	April 15, 1952	52
4	February 23, 1952	April 15, 1952	52
5	February 23, 1952	April 21, 1952	58
6	February 23, 1952	April 15, 1952	52
7	February 23, 1952	April 15, 1952	52
8	February 23, 1952	April 13, 1952	50
9	February 23, 1952	April 13, 1952	50
10	February 23, 1952	April 11, 1952	48
11	February 23, 1952	April 15, 1952	52
12	February 23, 1952	April 15, 1952	52
13	February 23, 1952	April 15, 1952	52
14	February 23, 1952	April 15, 1952	52
15	February 23, 1952	April 10, 1952	47
16	February 23, 1952	April 16, 1952	53
17	February 23, 1952	April 15, 1952	52
18	February 23, 1952	April 15, 1952	52
19	February 23, 1952	April 16, 1952	53
20	February 23, 1952	April 16, 1952	53
Average			51.80

[a] All the flowers studied were from Ponderosa Tree No. 20.

TABLE 3

Fruit set of Ponderosa under different methods of pollination

TREE NUMBER	OPEN-POLLINATION [a]			EMASCULATION BEFORE OPEN-POLLINATION			NATURAL SELF-POLLINATION [b]			ARTIFICIAL SELF-POLLINATION		
	Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set	
		Number	Percentage		Number	Percentage		Number	Percentage		Number	Percentage
4–A	100	1	1.00	100	0	0.00	100	0	0	100	0	0
6–A	100	2	2.00	100	2	2.00	100	0	0	100	0	0
10–A	100	4	4.00	100	1	1.00	100	0	0	100	0	0
4	100	3	3.00	100	2	2.00	100	0	0	100	0	0
12	100	2	2.00	100	0	0.00	100	0	0	100	0	0
20	100	0	0.00	100	1	1.00	100	0	0	100	0	0
25	100	5	5.00	100	3	3.00	100	0	0	100	0	0
26	100	2	2.00	100	2	2.00	100	0	0	100	0	0
Total	800	19		800	11		800	0	0	800	0	0
Average			2.38			1.38			0			0

[a] Emasculated a day before exposure to open-pollination.
[b] The flower clusters were bagged for 10 days.

TABLE 4

Fruit set of native chico under different methods of pollination

TREE NUMBER	OPEN-POLLINATION [a]			EMASCULATION BEFORE OPEN-POLLINATION			NATURAL SELF-POLLINATION [b]			ARTIFICIAL SELF-POLLINATION		
	Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set	
		Number	Percentage		Number	Percentage		Number	Percentage		Number	Percentage
T–6	250	38	15.20	250	10	4.00	250	25	10.00	250	100	40.00
T–8	250	35	14.00	250	10	4.00	250	23	9.20	250	95	38.00
T–23	250	46	17.14	250	11	4.40	250	30	12.00	250	103	41.20
T–30	250	42	16.80	250	15	6.00	250	28	11.20	250	98	39.20
Total	1000	161		1000	46		1000	106		1000	396	
Average			16.10			4.60			10.60			39.60

[a] Emasculated a day before exposure to open-pollination.
[b] The flower clusters were bagged for 10 days.

TABLE 5

Fruit set of Ponderosa pollinated with native chico

TREES INVOLVED IN CROSS	NUMBER OF FLOWERS POLLINATED	NUMBER OF FRUITS SET	PERCENTAGE OF FRUIT SET
T–6A × T–13	45	16	35.56
T–10A × T–13	45	12	26.67
T–4A × T–34	45	15	33.33
T–20 × T–34	45	12	26.67
T–25 × T–33	45	14	31.11
Total	225	69	
Average			30.67

TABLE 6

Fruit set of Ponderosa under different methods of pollination

TREE NUMBER	EXPOSED TO OPEN-POLLINATION			ARTIFICIALLY SELF-POLLINATED			HAND-POLLINATED WITH NATIVE			HAND-POLLINATED WITH SAWOE MANILA			HAND-POLLINATED WITH JAVA		
	Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set	
		Number	Percentage		Number	Percentage		Number	Percentage		Number	Percentage		Number	Percentage
T–8A	100	5	5.00	100	0	0	100	40	40.00	100	7	7.00	100	5	5.00
T–7A										60	10	16.67	60	4	6.67

TABLE 7

Fruit set of native chico pollinated with Ponderosa

TREES INVOLVED IN CROSS	NUMBER OF FLOWERS POLLINATED	NUMBER OF FRUITS SET	PERCENTAGE OF FRUIT SET
34 × 7A	100	0	0
13 × 25	100	0	0

TABLE 8

Damage of Gelechiidae moth on flowers of native chico [a]

TREE NUMBER	MONTH OF OBSERVATION	TOTAL NUMBER OF FLOWERS OBSERVED	NUMBER OF FLOWERS DAMAGED	NUMBER OF FLOWERS UNDAMAGED	PERCENTAGE OF FLOWERS DAMAGED
6	May	343	239	104	69.68
8	May	259	195	64	75.29
23	May	309	215	94	69.58
30	May	252	145	107	57.55
Total		1163	794	369	
Average					68.27

[a] Flowers from 50 clusters.

TABLE 9

Damage of Gelechiidae moth on flowers of Ponderosa chico [a]

TREE NUMBER	MONTH OF OBSERVATION	TOTAL NUMBER OF FLOWERS OBSERVED	NUMBER OF FLOWERS DAMAGED	NUMBER OF FLOWERS UNDAMAGED	PERCENTAGE OF FLOWERS DAMAGED
1–A	May	401	348	53	86.78
6–A	April	430	262	168	60.93
25	July	280	150	130	53.57
26	May	350	250	100	71.43
Total		1461	1010	451	
Average					68.11

[a] Flowers from 50 clusters.

TABLE 10

Period of receptivity in Ponderosa chico [a]

TIME OF POLLINATION	NUMBER OF FLOWERS SET [b]
6:00 a.m.	0
6:30	0
7:00	0
7:30	0
8:00	1
8:30	1
9:00	1
9:30	2
10:00	5
10:30	9
11:00	7
11:30	6
12:00	0
12:30 p.m.	0
1:00	0
1:30	0
2:00	0
2:30	0
3:00	1
3:30	1
4:00	1
4:30	1
5:00	1
5:30	0
6:00	0

[a] Determined from 20 Ponderosa flowers for each 30-minute period.
[b] Determined by cross-pollination with the native chico.

THREE METHODS OF EXTRACTING THE FIBER OF SANSEVIERIA TRIFASCIATA [1]

BIENVENIDO P. AGPAOA

WITH TWO TEXT FIGURES

The retted fibers of *Sansevieria trifasciata Prain.* were significantly weaker in tensile strength than the fibers obtained by the "sipit" method and the decorticating method, but they gave the highest mean weight of dry fibers in grams a leaf. The fibers from the "sipit" method were lighter in color than those extracted by retting or decortication.

Sansevieria sp. or *buntot tigre* is a common ornamental plant growing abundantly in the Philippines. It produces fiber similar to that of abacá and of pineapple, which is made into *piña* and *jusi*.[2] The possibility of using several species of Sansevieria as a source of hard fiber has been recognized for several years. The plant has never attained commercial importance, however, because of the lack of knowledge regarding its cultural requirements and the extraction of its fiber. This work was therefore undertaken in the Division of Perennial Crops and in the Central Experiment Station, College of Agriculture, Los Baños, Laguna, from November, 1952, to March, 1954, to study the influence of three methods of extraction on the quality and tensile strength of Sansevieria fiber and to learn more about the agronomic characteristics of the plant.

MATERIALS AND METHODS

The Sansevieria plant used in the experiment is a perennial, slow-growing, upstanding plant; its leaves, stiff and semicylindrical at the base, are 3 to 4 feet long and from 2 to 2½ inches wide, fleshy, and sharp-pointed at the tip (fig. 1). The leaves have alternate light- and dark-green irregular bands in a pattern similar to that of the tail of a tiger; hence, the local name *buntot tigre*.

Six hundred mature leaves of *Sansevieria trifasciata* Prain., measuring from 93 to 103 centimeters in length and 6.0 to 8.4 centimeters in width, from plants about six years old, were cut close to the base of the plants with a sharp knife. The leaves were piled together, mixed, and divided into three groups at random. Each group contained 200 leaves. Fourteen leaves from each group were taken at random for the three methods of extraction. The remaining leaves in each group were similarly processed for color determination.

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[1] Central Experiment Station Contribution No. 1738. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Agronomy under the direction of Dr. Pedro A. David.

[2] *Piña* cloth is made from pineapple fiber; *jusi* is made from a mixture of *piña* fiber and silk.

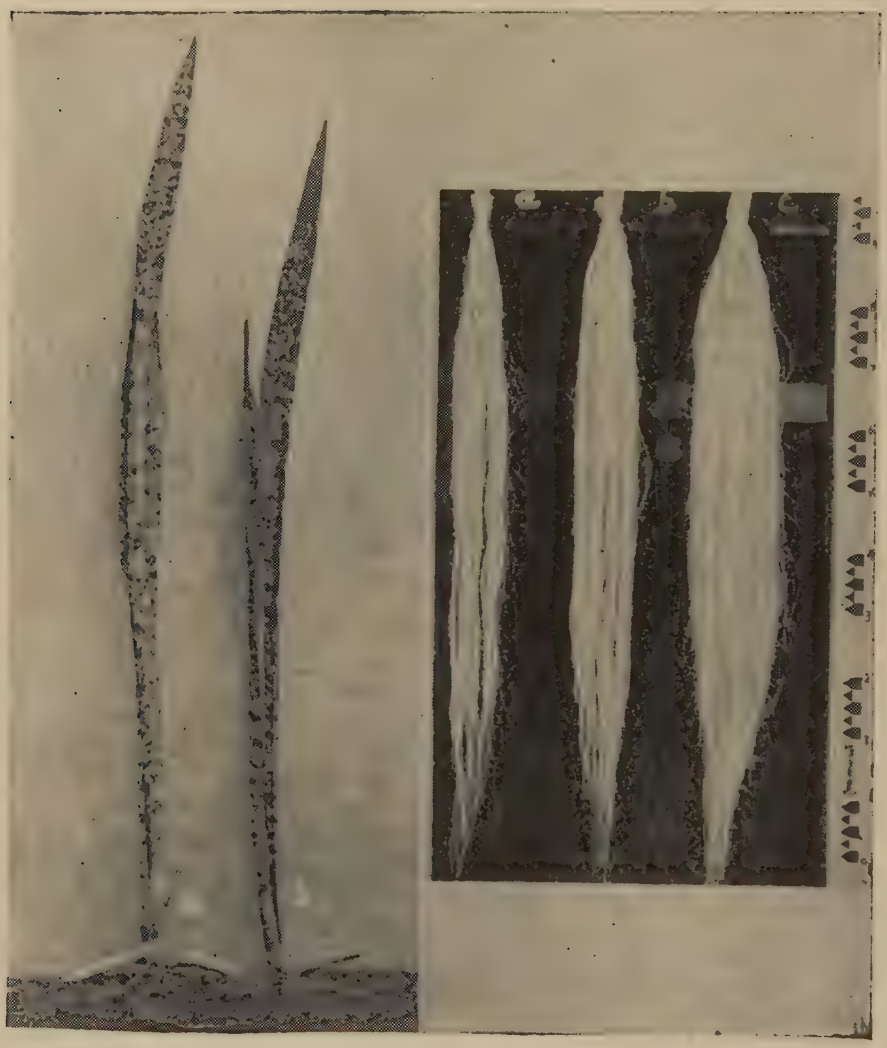

Fig. 1.—Left, mature *Sansevieria trifasciata* Prain.: (a) daughter plant; (b) mother plant. Right, Sansevieria fibers extracted by the three methods: (a) "sipit"; (b) decortication; and (c) retting. (*Photographed by the Photographic Division*).

Three methods of extracting Sansevieria fiber were compared, the "sipit," decorticating, and retting methods. In the "sipit" method, the weight and length of each leaf from the first pile were recorded, and a wooden label was tied to each leaf for identification. The leaves were gently and uniformly pounded before extraction of

Fig. 2.—Upper panel, a well-seasoned bamboo split ("sipit"). Lower panel, the "sipit" method of fiber extraction. (*Photographed by the Photographic Division*).

the fiber. They were pressed between the edges of the "sipit," which was made from well-seasoned bamboo with the nodes still at both ends (fig. 2, upper panel). The right foot of the operator (fig. 2, lower panel) kept the "sipit" in place. The fiber was pulled through the "sipit" several times to remove the pulp, washed thoroughly,

and dried in the shade. Then the percentage of the fiber extracted was determined and the color of the fiber noted.

Decorticating was done with a Mayon decorticating machine run by a 1½ to 2½ h.p. engine. The pulp of the leaves was not removed completely by the decorticating machine; the decorticated fibers were therefore washed to remove the remaining pulp and dried in the shade to a constant weight. The color of the dry fiber was noted and the percentage of fiber extracted was determined.

In the retting method of extracting fiber the leaves were gently and uniformly pounded, as in the "sipit" method, to hasten retting. The crushed leaves were properly labeled, bundled together, submerged in water, and turned over occasionally to insure uniform retting. After two weeks of retting, the leaves were thoroughly washed and dried in the shade. From then on they were treated as in the "sipit" and decortication methods of fiber extraction.

Samples of single-fiber strands taken at random from each leaf were prepared, and two trials were made for every leaf. A Scott Testers IP-2 tensilgraph machine was used to determine the breaking load of a single fiber strand. The following formula used by Botkin *et al.*[3] to determine the tensile strength of fibers was employed:

$$\text{Tensile strength (km.)} = \frac{\text{Breaking load}}{\text{Weight of sample per cm.}}$$

RESULTS AND DISCUSSION

Diseases and pests. The leaf cuttings planted during the rainy season were attacked by a bacterial soft rot disease. No serious pests attacked *Sansevieria trifasciata,* except for the Giant African snail (*Achatina fulica* Fer.) which ate the tips of the young leaves. This pest was not a problem, however, for it could be picked easily and crushed.

Amount of fiber. The method of extraction influenced significantly the weight of dry fiber produced (table 1). Only a small amount of dry fiber was obtained from the "sipit" method (fig. 1); hence, it should not be recommended for large-scale extraction of Sansevieria fiber.

Tensile strength. Fibers extracted by the "sipit" method gave the highest mean tensile strength (table 2). The difference between the tensile strength of the decorticated fibers and that of the fibers obtained from the "sipit" method, however, was not significant. The amount of fiber extracted by the retting method was large, but the fibers obtained were significantly weaker than the fibers from the

[3] C. W. Botkin, L. B. Shires, and E. C. Smith, *New Mexico Agric. Exper. Sta. Bull. 300* (1943).

other two methods. This is probably due to the length of time the fibers were soaked in water.

Length of fiber. The differences in mean length of fibers from the three methods of extraction were not statistically significant (table 3). Also, the fibers extracted by the three methods were not markedly shorter than the original length of the leaves (fig. 1).

Color of fiber. The fibers from the "sipit" method were pale cinnamon-pink; the decorticated fibers, pale pinkish buff; and the retted fibers, cartridge buff.[4]

[4] Robert Ridgway, "Color Standards and Color Nomenclature," A. Hoen and Co., Baltimore, Maryland, 1912, 42 pp.

TABLE 1

Weight in grams of dry fiber from one leaf

METHOD	REPLICATION														TOTAL	MEAN
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
"Sipit"	1.5	1.6	1.2	1.5	1.1	1.3	1.4	1.3	1.2	1.9	1.8	1.3	1.5	1.2	19.8	1.4
Decortication	3.2	3.0	3.1	2.8	2.8	3.1	2.7	3.5	2.2	2.4	1.8	2.0	2.5	3.0	38.1	2.7
Retting	3.8	3.9	3.8	3.7	3.9	3.0	3.7	3.1	3.2	2.8	3.3	3.2	2.5	2.1	46.0	3.3
Total	8.5	8.5	8.1	8.0	7.8	7.4	7.8	7.9	6.6	7.1	6.9	6.5	6.5	6.3	103.9	

Analysis of variance

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Methods	2	25.80	12.90	64.5	3.24	5.19
Plants within methods	39	7.82	0.20			
Total	41	33.62				

L.S.M.D. = 0.34

TABLE 2

Tensile strength in kilometers of Sansevieria fiber

REPLICATION	METHOD								
	"Sipit"			Decortication			Retting		
			Total			*Total*			*Total*
1	32.63	61.92	94.55	61.67	54.55	116.22	11.87	14.17	26.04
2	25.65	40.67	66.32	47.07	32.50	97.57	8.21	11.29	19.50
3	76.00	75.71	151.71	58.33	52.17	110.50	17.15	12.73	29.88
4	45.83	54.00	99.83	48.33	54.00	102.33	19.53	16.76	36.29
5	47.35	45.82	93.17	54.00	34.67	88.67	20.00	15.25	35.25
6	57.08	50.35	107.43	39.17	50.43	89.60	17.19	20.91	38.10
7	72.17	51.15	123.32	32.95	42.58	75.53	23.75	10.49	34.24
8	35.00	35.43	70.43	35.00	56.74	91.74	16.20	12.82	29.02
9	45.00	40.20	85.20	35.00	47.83	82.83	19.05	14.00	33.05
10	38.62	66.15	104.77	58.42	56.74	115.16	20.45	14.50	34.95
11	47.50	48.00	95.50	51.82	51.14	102.96	19.19	14.00	33.19
12	63.33	60.00	123.33	35.76	47.83	83.59	14.64	18.09	32.73
13	32.48	41.40	73.88	52.73	33.48	86.21	19.00	16.43	35.43
14	45.40	61.47	106.87	42.67	38.57	81.24	17.17	16.67	33.84
	Mean = 49.87			Mean = 46.65			Mean = 16.13		

Analysis of variance

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Method	2	19,418.8737	9,709.4369	78.8023	3.24	5.19
Plants	39	4,805.2900	123.2126			
Determinations within plants	42	2,621.0754	62.4066			
Total	83	26,845.2391				

L.S.M.D. = 4.26

TABLE 3

Length in centimeters of dry fiber from a leaf

METHOD	REPLICATION														TOTAL	MEAN	STANDARD ERROR	COEFFICIENT OF VARIABILITY (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14				
"Sipit"	99.6	100.0	102.5	97.8	95.0	93.2	99.0	95.3	97.4	98.2	100.0	93.4	92.1	97.5	1361.0	97.21	0.22	3.19
Decortication	106.4	94.8	99.0	95.8	99.4	100.3	99.8	99.1	96.3	93.0	97.1	90.4	92.2	98.0	1361.6	97.26	0.28	4.19
Retting	103.6	96.0	99.8	96.8	96.1	98.8	97.3	92.0	93.4	94.0	101.2	96.5	99.1	97.8	1361.6	97.26	0.22	3.16

CONTROL OF BUÑGA ÑG TUBO (AEGINETIA INDICA L.) WITH CHEMICAL WEED KILLERS [1]

JACINTO R. RIVERA

WITH THREE TEXT FIGURES

Buñga ñg tubo, *Aeginetia indica* L., a destructive phanerogamic root parasite of sugar cane, was controlled by spraying with 2,4-D amine and 2,4-D ester at concentrations of 0.40, 0.30, 0.20, and 0.10 per cent. Both forms of the herbicide had the same effect on the parasite and did not cause any visible injury to the host plant. At the seedling stage of the parasite, complete suppression was obtained with two applications of the herbicide at concentrations of 0.20, 0.30, and 0.40 per cent. Three applications were necessary to effect complete kill with 0.10 per cent. Two applications of any of the concentrations completely suppressed the parasite at the preflowering stage. The flowering stage of the parasite appeared to be most susceptible to the herbicide treatment. At this stage, complete suppression was obtained by spraying once with 0.10 per cent or the higher concentrations. The 0.10, 0.20, and 0.30 per cent solutions of 2,4-D amine or 2,4-D ester when sprayed twice on the leaves of the sugar cane did not affect the development of the parasite. Neither did they cause any deleterious effect on the host.

Buñga ñg tubo is a destructive phanerogamic root parasite of sugar cane which has been reported to attack upland rice, corn, various grasses, and a large number of other monocots. In the Philippines it seems to be more abundant or conspicuous on sugar cane than on any of its other hosts. This parasite causes a considerable reduction in the sugar content of the cane. In cases of heavy infection, it may cause as much as 60 per cent loss of sucrose (Espino, 1947).

Sugarcane planters try to prevent the spread of the parasite or destroy it altogether by cutting down the stalks or pulling out the whole shoot. This method, however, is inadequate and ineffective. It is also laborious and expensive especially in wide areas. Since chemical weed killers are now available in the market, it would be of interest to explore their possibilities for controlling buñga ñg tubo in sugarcane plantations.

The work of Agati and Tan (1931) showed the possibility of controlling the parasite with atlacide. Ocfemia (1935) reported very encouraging results in the test with sodium arsenite on *Aeginetia indica* on potted canes. Capinpin and Ocfemia (1948) stated that a solution of 1000 ppm. 2,4-D, when applied at the right stage, controlled the parasite.

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[1] Central Experiment Station Contribution No. 1739. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Plant Pathology under the direction of Assistant Professor Faustino T. Orillo.

To study the effects of herbicides on buñga ñg tubo and to determine the concentrations most effective against the different stages of development of the parasite and yet not injurious to sugar cane, this investigation was conducted from December, 1952, to February, 1954, in the laboratory of the Department of Plant Pathology of the College of Agriculture and Central Experiment Station and in sugarcane fields in Calamba, Laguna.

MATERIALS AND METHODS

For the laboratory experiments, two-node cuttings of POJ 2878 sugar cane, previously soaked in tap water for 48 hours, were each planted in a pot of good garden soil. When the plants were about one month old, they were fertilized with ammonium sulfate at the rate of 150 kilograms to the hectare or 10 grams to each pot culture.

Mature seeds of buñga ñg tubo were collected from infested sugarcane fields in Calamba, Laguna. On March 1, 1953, when the sugarcane plants were about two months old, the minute seeds were sown around the base of the plants at the rate of 200 milligrams to a pot culture. The plants were watered everyday and were regularly given the necessary care. On July 8, 1953, that is, five months after sowing, the parasites started to emerge from the soil.

For the field experiments, one-square-meter lots were staked off in a selected portion of a sugarcane field infested with buñga ñg tubo. The stages of development and the number of stools of the parasite in each lot were recorded.

The herbicides [2] used in this study are briefly described below:

1. Hi-ester 2,4-D Weed Killer:—Selective; liquid; contains 2,4-Dichlorophenoxyacetic acid, isopropyl ester 50.2 per cent and 2,4-Dichlorophenoxyacetic acid, propyleneglycol (C_3H_6O to $C_9H_{13}O_3$) Butyl ether esters 32.6 per cent as active ingredients; total active ingredients, 82.8 per cent.

2. Du Pont 2,4-D Amine Weed Killer:—Selective, liquid; contains 49.6 per cent Dimethylamine and 2,4-Dichlorophenoxyacetic acid as active ingredients.

Three concentrations were used in the laboratory test: the recommended concentration or one used by previous workers, a high concentration, and one intermediate between the two. In addition to these three concentrations, a still higher one was tested in the field. The herbicides were prepared as aqueous solutions. The concentrations were based on the percentage of active ingredients of the materials. In both laboratory and field trials, the chemicals were applied at the rate of one liter for every five square meters.

A Spra-well and a Hudson Continuous sprayer were used to spray the herbicides. The sprayers were washed before and after using to prevent contamination of the chemicals and concentrations. Except

[2] Obtained from the Shell Company of P. I., Ltd., and from Macondray and Co., Inc., Manila.

when certain stages of the parasite appeared tolerant to the chemical, only one application of each concentration was made. The parasite was sprayed at the seedling, preflowering, and flowering stages of its development. Treatments were made on calm, clear days between six and nine o'clock in the morning. During the experiments, no rain fell within 24 hours after treatment. Before spraying, the pot cultures and field lots were labeled with the treatment they were to receive. Controls were maintained for comparison. The stools and stalks of the parasite in each pot culture and lot were counted before and after treatment.

Inasmuch as 2,4-D is a plant hormone, it was determined whether or not this substance when applied to the host would be translocated from the leaves to the roots and thence through the haustoria and stalks of the parasite. The advantage of direct application on the host is that in the field the sprayer need not look for the parasite, which is hidden by the foliage of the cane (Capinpin and Ocfemia, 1948).

RESULTS AND DISCUSSION

Laboratory trials

The experiments described below were conducted to determine the most effective concentration of 2,4-D ester and amine for the control of the parasitic flowering plant at different stages in its development without injuring the host plant. Since the parasite in each pot culture did not produce uniform growth, its stalks at the seedling, preflowering, and flowering stages of its development were counted separately before the herbicide was applied.

Experiment 1. On August 6, 1953, the stalks of *Aeginetia indica* in pot cultures were thoroughly sprayed with 0.10, 0.20, and 0.30 per cent 2,4-D ester separately. After 24 hours, bending of the seedling stalks was observed in all the treated cultures, but the control remained erect. Three to four days after, the color of the stalks changed from purple to reddish yellow. One week later, the treated parasite showed very pronounced bending and twisting of the stalks (fig. 1, upper panel). The tips of the shoots which were treated with higher concentrations (0.20 and 0.30 per cent) of the herbicide turned black. The bending and twisting of the stalks in the preflowering stage occurred within two days after the application of the herbicide. Necrosis of the flowers was noted in the flowering stalks two to three days after treatment. One week after spraying, new growth was observed. It was noted that the new growth consisted of the shoots which had not yet emerged from the soil at the time of the first spraying. Vigorously growing seedlings, especially those treated with the lower concentration (0.10 per cent), appeared to be slightly tolerant to the herbicide. Counts of new growth and of old sprayed stalks which appeared tolerant to the herbicide were made before the second spraying (table 1a).

Nine days after the first spraying, a second one was performed. A week later, the parasite began to dry up. Twenty-one days after

Fig. 1.—Upper panel, effects of 0.10 per cent concentration of 2,4-D ester on *Aeginetia indica* one week after the first spraying. The treated parasites showed pronounced bending and twisting of the flower stalks. Lower panel, effects of 0.10 per cent concentration of 2,4-D ester on *Aeginetia indica* 21 days after the second spraying. The treated parasites had totally dried up, but the untreated ones (left) remained healthy. (*Photographed by the Photographic Division, College of Agriculture.*)

the second spraying, when the parasite had completely dried up (fig. 1, lower panel), final counts were made. All the treated stools were totally killed (table 1a). Thereafter, no new growth of the parasite was observed up to the termination of the study. A second test conducted on September 14, 1953, showed the same results as the first (table 1b). In both experiments the host plants of the treated *Aeginetia indica* remained as healthy as those of the check.

Experiment 2. To determine whether 2,4-D amine would produce the same effect as 2,4-D ester, an experiment was conducted on September 14, 1953. The concentrations used were the same as those used in experiment 1. Within 24 hours after the treatment, the effects of the amine, which were similar to those observed in the preceding experiment, were shown by the sprayed parasite. Bending, twisting, and blackening of the tips of the stalks were observed. New growth and tolerant stalks were noted after the first spraying. These were counted before the second spraying (table 2) which was performed nine days after the first one. The final count was made 21 days after the second treatment when the sprayed parasite had completely dried up (fig. 2, upper panel). All the treated stalks were killed (table 3). Unlike in the control, no new growth was observed until December, 1953. No deleterious effects of the herbicide were observed upon the host, which remained as healthy as that of the untreated parasite.

The results of this laboratory experiment show that 2,4-D amine and 2,4-D ester have the same herbicidal effect on *Aeginetia indica.* The parasite could be readily controlled by spraying twice with either 2,4-D ester or amine at 0.30, 0.20, or even as low as 0.10 per cent concentration without the host being visibly injured.

Experiment 3. On August 6, 1953, the leaves of the sugar cane were sprayed separately with 0.10, 0.20, and 0.30 per cent 2,4-D ester and amine. Care was taken not to wet the parasite with the herbicide solution. Two applications at 15-day interval did not affect the development of the *Aeginetia indica.* Neither did the three concentrations of the herbicide have any visible effects on the leaves of the sugar cane. The results of this experiment corroborate those obtained by Capinpin and Ocfemia in 1948.

Field trials

Capinpin and Ocfemia (1948) pointed out that a solution of 1000 ppm. 2,4-D, if applied on *Aeginetia indica* Linn. at the right stage of its development, controls the parasite. These authors suggested that spraying should be done just before or during the flowering stage to kill the entire plant and prevent production of seeds for dissemination.

Field experiments were conducted to determine at what stage of development the parasite would be readily killed with a given concentration of 2,4-D amine or 2,4-D ester. Lots with more or less

Fig. 2.—Upper panel, effects of 0.10 per cent concentration of 2,4-D amine on *Aeginetia indica* 21 days after the second spraying. The treated parasites had totally dried up; the untreated ones (left) remained normal. Lower panel, effects of 0.10 per cent concentration of 2,4-D ester on *Aeginetia indica* at its seedling stage in the field. Note the new growth directly arising from among the old sprayed stalks 14 days after the final count. (*Photographed by the writer.*)

uniform growth of the parasite were selected in an infested sugarcane field.

Seedling stage. On September 20, 1953, the parasite at the seedling stage was sprayed with 0.10, 0.20, 0.30, and 0.40 per cent 2,4-D amine and ester. One day after treatment, effects similar to those observed in the laboratory experiments were noted. The treated parasite wilted. The tips coiled and finally the stalks became black. One week after, new growth, aside from the seedlings which apparently were not killed by the first spray, was noted. The new growth and the stalks which recovered from the herbicide treatment were counted. The percentage of destruction based on old growth counts was determined (table 3). A second treatment was given nine days after the first. Twenty-one days after the second treatment, the parasite had completely dried up (table 3). Two weeks after the final count, however, new growths appeared again in lots treated with 0.10 per cent concentration. It was observed that the new growths, which consisted of stunted stalks, directly arose from among the old sprayed stalks (fig. 2, lower panel). Apparently the 0.10 per cent concentration of either 2,4-D amine or ester did not affect the underground parts of some stools of the parasite. The stools which produced new growths after the second treatment were examined and found to have fresh underground parts. These parts apparently were slightly or not at all affected by the previous sprays; hence, new growths arose from them. A third application of the herbicide completely destroyed the parasite.

Preflowering stage. On September 27, 1953, the herbicidal solutions were applied on *Aeginetia indica* at its preflowering stage. The concentrations used were the same as those used in the previous experiments. One day after treatment, effects similar to those described in the preceding tests were noted. The bending and twisting of stalks occurred in two to three days. New growth and apparently herbicide-tolerant stalks were observed and counted. The percentage of destruction based on old growth counts was determined (table 4). A second spraying was done nine days after the first. Twenty-one days after the second spraying, the parasite had completely dried up (fig. 3, upper panel). No new growth was observed thereafter. The herbicides had no visible effect upon the host plants. Examination of the dead parasite revealed that the underground parts were rotten at the point of attachment to the sugarcane roots, but the latter were not affected.

Flowering stage. On October 4, 1953, new lots infested with the parasite at its flowering stage were sprayed with the two forms of 2,4-D at the same concentrations as those used in the preceding experiments. The bending and twisting of the tips of the stalks and the necrosis of the flowers occurred within two to three days. The capsules bearing the young seeds dried prematurely. Thirty days after treatment, the parasites had completely dried up (fig. 3, lower panel). Rotting of the underground parts was noted. Unlike in

Fig. 3.—Upper panel, *Aeginetia indica* at its preflowering stage totally killed by the spray of 0.10 per cent concentration of 2,4-D ester, 21 days after the second spraying. Lower panel, *Aeginetia indica* at its flowering stage in the field totally killed by the spray of 0.10 per cent concentration of 2,4-D ester, 21 days after the second spraying. (*Photographed by the writer.*)

the previous experiments, no new growth was observed after the first spraying (table 5).

From the above field experiments, it appears that *Aeginetia indica* in sugarcane fields can be sprayed with either 2,4-D amine or ester with satisfactory results. For the seedling stage, three applications of the 0.10 per cent solution or two applications of the higher concentrations (0.20, 0.30, or 0.40 per cent) were necessary for complete suppression of the parasitic flowering plant. The preflowering and flowering stages of the parasite seemed to be more susceptible to the herbicide treatment. At the preflowering stage, the parasite could be completely suppressed by spraying twice with 0.10 per cent solution of 2,4-D. One application of the same concentration effected complete kill when the parasite was treated at the flowering stage. The dosages which proved lethal to the parasite apparently had no injurious effect upon the host.

Effects of the herbicide on Aeginetia indica Linn. Green (1953) pointed out that extracts containing hormone herbicide can induce numerous responses in growing plants. At relatively high concentrations, however, the chemical brings about the death of certain plants as a result of its profound effect on the life processes of the plants. According to Swanson (1946), the effect of 2,4-D is systemic in nature even at relatively low concentrations.

In this study, various responses were evident after the application of the herbicide on the parasite at its different stages of development. Among the observable responses were the wilting of shoots, coiling accompanied by discoloration of the stalks, and, in the flowering stage, rapid drying up of the capsules bearing the newly formed seeds. In extreme cases, there was rotting of the base of the stalks below soil level.

The differences in sensitivity to the herbicide of the seedling, preflowering, and flowering stages of the parasite seemed to be due not so much to the physiological reactions of these different growth stages to the ingredients of the herbicides as to the relative differences in size or area exposed to the spray. As the *Aeginetia* produced only shoots during the seedling and preflowering stages, not much of the herbicide solution could possibly penetrate to affect the physiology of the parasite on account of its smooth surface and its almost vertical position. Perhaps one application of the herbicide was not enough to destroy the parasite completely because in its seedling and preflowering stages, not all the germinated seeds had yet emerged through the soil. What was destroyed by the first application of the herbicide was the part above the ground of the shoots that had already emerged.

On account of the longer stalks and the flowers at the flowering stage of the parasite, a greater surface area was exposed to the

spray. The flowers were completely wet with the spray. Consequently, the film of the herbicide solution remained for a longer period on the flowers, thereby allowing ample time for absorption into the plant tissues.

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TABLE 1a

Effects of the different concentrations of 2,4-D ester on Aeginetia indica Linn.[a]

CONCENTRATION	CULTURE POT NO.	STAGE OF DEVELOPMENT	INITIAL COUNT	AFTER THE FIRST SPRAYING[b]		AFTER THE SECOND SPRAYING[c]	
				Old growth	New growth	Final count	Percentage killed
per cent			*stools*	*stools*	*stools*	*stools*	
Control	1	S	11	4	7		
		P	29	11			
		F	2	21		53	
0.10	2	S	16	11	3		
		P	32	22		0	100
		F	8	1			
	3	S	8	6	5		
		P	22	11		0	100
		F	2	1			
Control	1	S	16	4	6		
		P	22	22			
		F	2	24		56	
0.20	2	S	17	16	4		
		P	29	26		0	100
		F	4	1			
	3	S	12	10	3		
		P	27	22		0	100
		F	8	2			
Control	1	S	14	3	4		
		P	28	14			
		F	5	33		54	
0.30	2	S	13	9	4		
		P	29	13		0	100
		F	6	1			
	3	S	12	8	3		
		P	29	12		0	100
		F	9	2			

[a] Sprayed twice at interval of nine days.
[b] Nine days after the first spraying.
[c] Twenty-one days after the second spraying.
S—Seedling.
P—Preflowering.
F—Flowering.

TABLE 1b

Effects of the different concentrations of 2,4-D ester on Aeginetia indica Linn.[a]

CONCENTRATION	CULTURE POT NO.	STAGE OF DEVELOPMENT	INITIAL COUNT	AFTER THE FIRST SPRAYING[b]		AFTER THE SECOND SPRAYING[c]	
				Old growth	New growth	Final count	Percentage killed
per cent			*stalks*	*stalks*	*stalks*	*stalks*	
Control	1	S	14	4	6		
		P	12	14			
		F	5	17		41	
0.10	2	S	15	12	2		
		P	16	12		0	100
		F	2	1			
	3	S	14	12	2		
		P	28	20		0	100
		F	6	1			
Control	1	S	18	6	6		
		P	20	18			
		F	3	23		53	
0.20	2	S	10	10	5		
		P	28	22		0	100
		F	10	2			
	3	S	11	9	2		
		P	18	11		0	100
		F	6	2			
Control	1	S	14	6	5		
		P	18	15			
		F	4	22		48	
0.30	2	S	12	7	3		
		P	24	9		0	100
		F	5	1			
	3	S	10	6	2		
		P	23	6		0	100
		F	3	1			

[a] Sprayed twice at interval of nine days.
[b] Nine days after the first spraying.
[c] Twenty-one days after the second spraying.
S—Seedling.
P—Preflowering.
F—Flowering.

TABLE 2

Effects of the different concentrations of 2,4-D amine on Aeginetia indica Linn.[a]

CONCENTRATION	CULTURE POT NO.	STAGE OF DEVELOPMENT	INITIAL COUNT	AFTER THE FIRST SPRAYING [b]		AFTER THE SECOND SPRAYING [c]	
				Old growth	New growth	Final count	Percentage killed
per cent			*stalks*	*stalks*	*stalks*	*stalks*	
Control	1	S	9	3	4		
		P	20	9			
		F	14	34		50	
0.10	2	S	12	10	5		
		P	25	16		0	100
		F	3	1			
	3	S	10	8	5		
		P	16	12		0	100
		F	5	1			
Control	1	S	13	2	3		
		P	18	13			
		F	6	24		52	
0.20	2	S	8	6	5		
		P	15	4		0	100
		F	8	2			
	3	S	10	6	3		
		P	22	10		0	100
		F	6	0			
Control	1	S	7	2	5		
		P	21	9			
		F	5	26		42	
0.30	2	S	11	5	5		
		P	25	10		0	100
		F	8	1			
	3	S	12	6	5		
		P	28	5		0	100
		F	5	1			

[a] Sprayed twice at interval of nine days.
[b] Nine days after the first spraying.
[c] Twenty-one days after the second spraying.
S—Seedling.
P—Preflowering.
F—Flowering.

TABLE 3

Effects of the different concentrations of 2,4-D amine and ester on seedlings of Aeginetia indica Linn.[a]

HERBICIDE	CONCENTRATION	INITIAL COUNT	AFTER THE FIRST SPRAYING[b]			AFTER THE SECOND SPRAYING[c]		REMARKS
			Old growth	New growth	Percentage killed	Final count	Percentage killed	
	per cent	*stools*	*stools*	*stools*		*stools*		
Amine	Control	26		9		55		Stools at fruiting stage during final count.
	0.10	25	20	5	20.0	0	100	New growth appeared 14 days after the final count. Growth composed of 2 stools with 6 and 5 stalks, respectively. Third spraying completely suppressed the parasite.
	0.20	28	19	4	32.1	0	100	No new growth appeared after the final count. Herbicide had no visible effect on host.
	0.30	35	18	6	48.6	0	100	No new growth appeared after the final count. Herbicide had no visible effect on host.
	0.40	30	10	3	66.7	0	100	No new growth appeared after the final count. Herbicide had no visible effect on host.
Ester	Control	22		8		30		Stools at fruiting stage during the final count.
	0.10	23	18	2	21.7	0	100	New growth appeared after the final count. Growth composed of 5 stunted stalks. Third spraying completely suppressed the parasite.
	0.20	22	14	5	36.4	0	100	No new growth appeared after the final count. Herbicide had no visible effect on host.
	0.30	25	13	4	48.0	0	100	No new growth appeared after the final count. Herbicide had no visible effect on host.
	0.40	28	9	3	67.9	0	100	No new growth appeared after the final count. Herbicide had no visible effect on host.

[a] Sprayed twice at interval of nine days.
[b] Nine days after the first spraying. Percentage killed based on old initial counts.
[c] Twenty-one days after the second spraying.

TABLE 4

Effects of the different concentrations of 2,4-D amine and ester on the pre-flowering stage of Aeginetia indica Linn.[a]

HERBICIDE	CONCENTRATION	INITIAL COUNT	AFTER THE FIRST SPRAYING[b]			AFTER THE SECOND SPRAYING[c]	
			Old growth	New growth	Percentage killed	Final count	Percentage killed
	per cent	*stools*	*stools*	*stools*		*stools*	
Amine	Control	18		6		24	
	0.10	20	14	4	30.0	0	100
	0.20	22	13	3	40.9	0	100
	0.30	22	8	1	63.6	0	100
	0.40	25	7	4	72.0	0	100
Ester	Control	24		6		30	
	0.10	21	14	3	33.3	0	100
	0.20	21	12	4	42.9	0	100
	0.30	20	7	2	65.0	0	100
	0.40	22	6	3	72.7	0	100

[a] Sprayed twice at interval of nine days.
[b] Nine days after the first spraying. Percentage killed based on old initial counts.
[c] Twenty-one days after the second spraying.

TABLE 5

Effects of the different concentrations of 2,4-D amine and ester on the flowering stage of Aeginetia indica Linn.[a]

HERBICIDE	CONCENTRATION	INITIAL COUNT	FINAL COUNT[b]	PERCENTAGE KILLED
	per cent	*stools*	*stools*	
Amine	Control	25	25	
	0.10	22	0	100
	0.20	26	0	100
	0.30	30	0	100
	0.40	29	0	100
Ester	Control	28	28	
	0.10	25	0	100
	0.20	20	0	100
	0.30	22	0	100
	0.40	24	0	100

[a] Sprayed only once.
[b] Thirty days after treatment.

RELATION OF THREE METHODS OF EXTRACTING KENAF FIBER TO TENSILE STRENGTH [1]

SEVERINO F. CAPULONG

WITH FOUR TEXT FIGURES

The tensile strength of the fiber of kenaf, *Hibiscus cannabinus* Linn., extracted by the retting method was superior to that of the fibers extracted either chemically or by decortication. The efficiency of fiber extraction was highest for the retting method, next highest for the decortication method, and lowest for chemical extraction. In length, color, softness, and luster of fibers, the retting method ranked first; decortication, second; and chemical extraction, third.

Dew-retting, decortication, water-retting, and chemical extraction are used in extracting the fiber of kenaf (*Hibiscus cannabinus* Linn.). Since the method of extraction directly influences the quality of the fiber, it is important that the best method be determined. This study was conducted from May, 1953, to March, 1954, in the Department of Agronomy, UP College of Agriculture, Los Baños, Laguna, to compare three methods of extracting kenaf fiber and to determine their effects on the tensile strength, length, color, and yield of fiber.

Ergle, Robinson, and Dempsey (1934) found that kenaf fibers from water-retted plants were superior in strength and quality to those from dew-retted plants. Samples of kenaf fibers retted in water at temperatures of 22°C. to 25°C. had a higher tensile strength than samples obtained at 34°C., according to Watkins and Allwood (1948). Manzano (1952) reported that the tensile strength of fibers retted in running water did not differ significantly.

MATERIALS AND METHODS

A fairly well-drained Lipa clay loam soil with an area of 300 square feet was plowed twice with a tractor and harrowed several times after each plowing. The lot was divided into 17 rows; the extreme two rows were made guard rows.

Kenaf seeds of the *vulgaris* variety obtained from Soriano and Sons Company, Manila, were planted on May 20, 1953. They were sown thickly in furrows and covered with fine soil. Two weeks after planting, when the seedlings were about six inches tall, the plants were cultivated and thinned, leaving only the healthy seedlings with two to three inches between hills. The plants were further thinned so that only one plant remained in a hill. Cultivation was done with a trowel throughout the experiment.

[1] Central Experiment Station Contribution No. 1740. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Agronomy under the direction of Associate Professor Pedro A. David.

Seedlings attacked by *Sclerotium rolfsii* Sacc.[2] were sprayed with 20 grams of 350 Cop, a fungicide, dissolved in 2 gallons of water. A second spraying of 350 Cop solution was done to further control the disease. Another fungus caused by *Phoma sabdariffae* Sacc. was checked by spraying the plants with 20 grams of Spray Cop powder dissolved in 2 gallons of water.

Plants attacked by *Dysdercus megalopygus* Breddin, *D. poecilus* Herrich Shaeffer, and *Nisotra gemella* Erichson[3] were sprayed with 10 grams of Gesarol "50," an insecticide, dissolved in 2 gallons of water.

Harvesting was done when the plants were at the blooming stage. Four plants were harvested from a row at random; they were cut at ground level with a bolo. The harvested stalks were tied in bundles, weighed, and then extracted of their fiber by three methods—chemical, decortication, and retting.

The solution for the chemical method was prepared by dissolving 7 pounds of ammonium sulfate and 20 pounds of 4 per cent sodium hydroxide in 400 gallons of water. The stripped bark ribbons were dipped in the constantly agitated solution at 60°C. to 65°C. for one hour (fig. 1). In the decortication method, the harvested kenaf stalks were fed, base first, to a ramie decorticating machine (fig. 2). In the retting method, the whole bundles of kenaf stalks were immersed for seven to eight days in a retting tank filled with water (fig. 3).

The fibers produced in each treatment were thoroughly washed in clean water to remove the pulp and gum. The clean fibers were dried under the sun to a constant weight, and then the weight was recorded.

A Scott Tester IP-2 Tensilgraph machine was used to determine the breaking load of samples of single-fiber strands taken from the fibers extracted by the different methods. There were 120 trials for each of the three methods of extraction.

The tensile strength, expressed in breaking length, was computed by using the following formula of Botkin, Shires, and Smith (1943):

$$\text{Tensile strength} = \frac{\text{Breaking load}}{\text{Weight of sample per cm.}}$$

RESULTS AND DISCUSSION

The method of extraction greatly influenced the color, softness, and luster of the fibers. The fibers obtained by retting was superior

[2] The two diseases mentioned in this paper were identified by Dr. Faustino T. Orillo of the Department of Plant Pathology.

[3] The three insects were identified by Dr. Silverio M. Cendaña of the Department of Entomology.

Fig. 1.—Chemical retting of kenaf fibers: (t) thermometer, (bp) big pan, (br) bark ribbon, (fd) fire drum, (s) solution [water, NaOH, $(NH_4)_2SO_4$]. (*Photographed by Dr. Julian Banzon of the Photographic Division*).

Fig. 2.—Ramie decorticating machine showing (ks) kenaf stalk, (b) belt, and (e) engine. (*Photographed by Dr. Julian Banzon of the Photographic Division*).

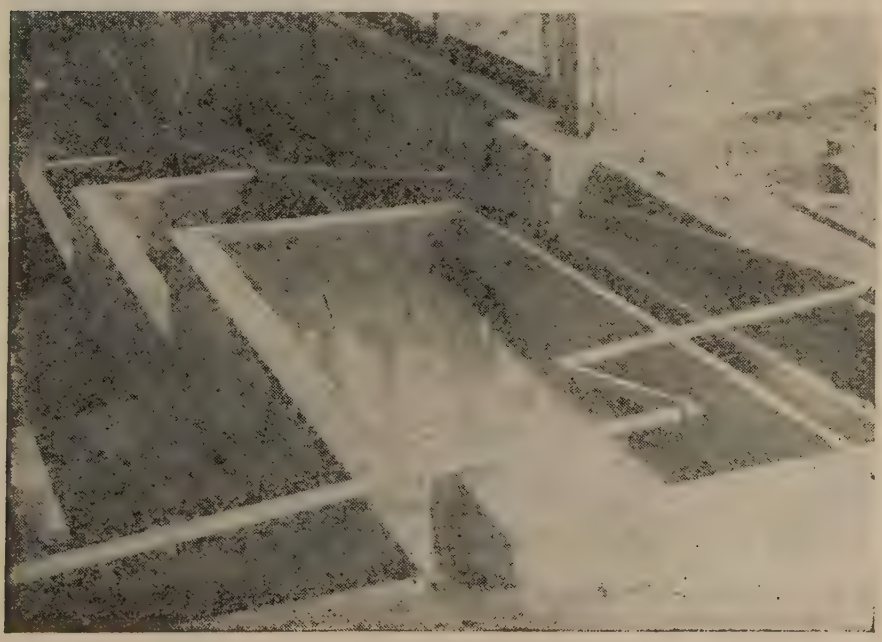

Fig. 3.—Retting tank. (*Photographed by Dr. Julian Banzon of the Photographic Division*).

Fig. 4.—Lengths of the fibers extracted by the different methods: R—retted fibers, D—decorticated fibers, and C—chemically treated fibers. (*Photographed by Dr. Julian Banzon of the Photographic Division*).

in these three qualities to those obtained by either decortication or chemical extraction.

The color of the fibers ranged from creamy white to grayish white for the retted fibers and brownish to dark brown for the chemically treated fibers. The decorticated fibers were greenish white. The colors of the fibers were determined according to the standards of color of Maerz and Paul (1950).

A comparison of the lengths of the fibers produced in each of the three methods showed that the retted fibers were long, the chemically treated fibers short, and the decorticated ones intermediate between the two (fig. 4).

Table 1 shows that the mean tensile strength of the retted fibers was higher than that of the fibers produced by either of the two other methods. The decortication method gave a significant mean tensile strength over the chemical method. There were samples that gave a low tensile strength in the chemical and decortication methods. This low tensile strength is attributed to the diseases that attacked the plants before they were harvested. Using the retting method of extraction, Manzano (1952) obtained only 24.91 kilometers tensile strength. The mean tensile strength of retted and decorticated fibers is comparable to that obtained by Ergle *et al.* (1934).

The retting method gave the highest percentage of extraction (table 2). The differences in percentage of extraction between the retted and the chemically treated fibers and between the decorticated and the chemically treated fibers were significant.

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TABLE 1

Tensile strength in kilometers of fibers extracted by three different methods

FIBER	TREATMENT			TOTAL
	Retting	Decortication	Chemical	
1	24.24	16.05	13.89	56.18
2	33.63	28.34	28.17	90.14
3	25.42	34.80	27.96	88.18
4	29.09	23.12	25.84	78.05
5	28.17	32.63	23.75	84.55
6	25.51	21.67	18.72	65.90
7	32.57	26.50	13.23	72.30
8	33.25	26.75	13.92	73.92
9	25.04	33.96	18.24	77.24
10	32.50	13.97	20.42	66.89
11	30.63	28.75	20.16	79.54
12	29.63	30.96	19.88	80.47
13	23.04	13.21	21.78	58.03
14	24.84	20.42	16.67	61.93
15	31.15	23.61	16.63	71.39
16	30.47	23.17	28.55	82.19
17	33.86	22.41	15.65	71.92
18	28.40	23.52	17.17	69.09
19	31.69	24.84	18.04	74.57
20	26.15	29.50	28.55	84.20
Total	579.28	498.18	409.22	1,486.68
Mean	28.96	24.91	20.46	

Analysis of variance

SOURCE OF VARIANCE	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Methods	2	723.52	361.76	14.49	3.16	5.00
Error	57	1423.01	24.97			
Total	59	2146.53				

L.S.M.D. = 3.316

TABLE 2

Percentage recovery of fiber as influenced by three different methods of extraction

REPLICATION	TREATMENT			TOTAL
	Chemical	Retting	Decortication	
1	0.25	0.50	0.34	1.09
2	0.38	0.57	0.46	1.41
3	0.32	0.55	0.65	1.52
4	0.52	0.61	0.37	1.50
5	0.42	0.55	0.42	1.39
Total	1.89	2.78	2.24	6.91
Mean	0.38	0.56	0.45	

Analysis of variance

SOURCE OF VARIANCE	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Methods	2	0.0804	0.0402	4.49	3.88	6.93
Error	12	0.1075	0.00896			
Total	14	0.1879				

L.S.M.D. = 0.1286

DURABILITY OF LOCAL ROPES FOR TETHERING CATTLE [1]

VALENTE VILLEGAS

WITH ONE TEXT FIGURE

Of the eight kinds of ropes tested, yunot (*Arenga saccharifera* [Wurmb.] Labill.) rope was the most durable. Maguey, abacá, and danglin (*Grewia multiflora* Juss.) ropes were intermediate in durability. Labayo (*Melochia umbellata* [Houtt.] Stapf) rope was weak, but not weaker than coir, buri (*Corypha elata* Roxb.), and spiny bamboo (*Bambusa spinosa* Roxb.) ropes. Spiny bamboo rope was the weakest. Labayo, danglin, buri, maguey, and abacá ropes broke less often than coir, yunot, and spiny bamboo ropes. Spiny bamboo rope had the highest incidence of breakage and the lightest final weight. The rest were about the same in final weight and length. Abacá and spiny bamboo ropes were the shortest.

Handmade ropes of abacá, or Manila hemp fiber, maguey, labayo (*Melochia umbellata* [Houtt.] Stapf), danglin (*Grewia multiflora* Juss.), coir of coconut, kaong or yunot (*Arenga saccharifera* [Wurmb.] Labill.), buri or buntal (*Corypha elata* Roxb.), and spiny bamboo (*Bambusa spinosa* Roxb.) were tested in the Department of Animal Husbandry of the College of Agriculture, Los Baños, for 17 months, from February 2, 1951, to August 2, 1952, to determine (1) their durability for tethering, (2) the number of times they broke during their period of usefulness, and (3) their final weights and lengths.

The abacá ropes used were made in the barrio of Tinorik, Tanauan, Batangas. The maguey ropes came from Valencia, Bohol. The rest of the ropes were made in the barrio of Mayondon, Los Baños, Laguna.

METHOD OF STUDY

At the beginning of the work, the seven native cows used had an average age of six years and an average weight of 255.6 kilograms. Five ropes of each kind were tested on the different cows during the dry and wet seasons of the year. One end of the rope rotated within a loop connected to the halter so that twisting was avoided. The cows were tethered in level pastures devoid of stumps and weeds. At a little past 7 o'clock each morning, the animals were watered and moved to better grazing areas. In the afternoon between 2 and 3 o'clock, the cows were brought to the water tank and then transferred to fresh areas for grazing. On dry, bright, and warm days, the animals were placed in the shade. Whenever the cows were transferred from one place to another, the ropes were coiled and held in the hand.

During the trial, the ropes broke at different points. When this happened, the broken ends were tied together after the manner of

[1] Central Experiment Station Contribution No. 1741. Read before the Los Baños Biological Club on August 28, 1953.

an overhead knot. The investigation was considered over when the ropes became too short to permit the animals to graze and consume sufficient forage when they were tethered. At the end of the trial, each rope was dried, measured, and weighed.

RESULTS

Durability. The least durable of the ropes was spiny bamboo rope (fig. 1) which lasted for a mean of 45.8 ± 8.58 days, the range

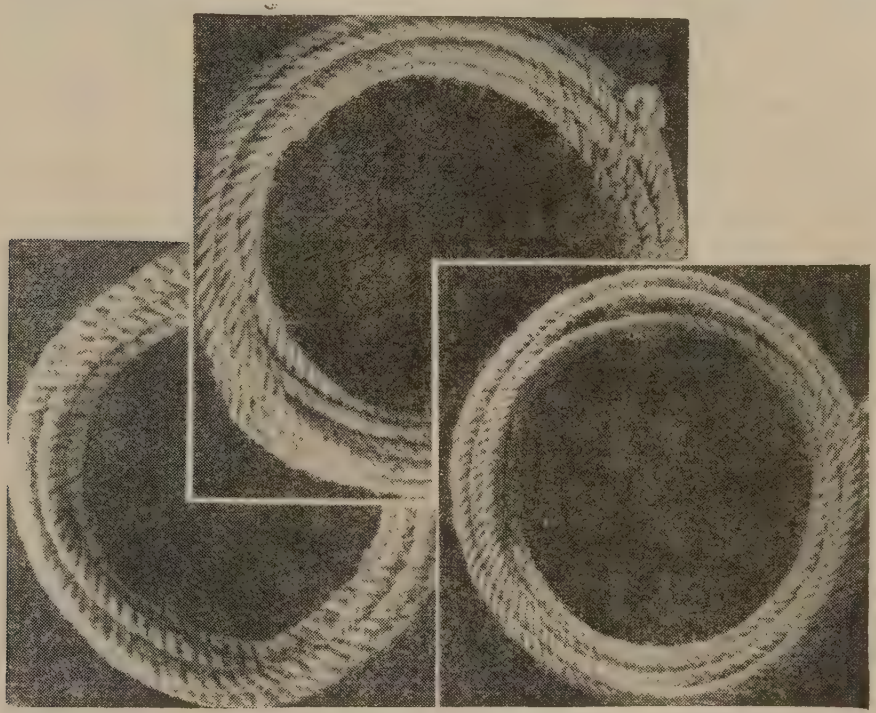

Fig. 1.—Three of the ropes tested: upper center, spiny bamboo rope; lower left, coconut coir rope; and right, buri, or buntal rope.

being from 21 to 72 days. Buri rope was next with a mean of 52.6 ± 9.90 days; the variation was from 19 to 73 days. Coir rope was third with a mean duration of 68.2 ± 13.86 days, the range being from 45 to 122 days. Labayo rope was fourth with a mean duration of 80.0 ± 13.06 days and a range of 45 to 125 days. Danglin rope was better with a mean duration of 86.6 ± 9.50 days, the range being from 68 to 118 days. Abacá rope, contrary to expectation, was next to danglin rope in durability. It lasted for 90.0 ± 10.03 days; the variation was from 53 to 112 days. Maguey rope had a mean duration of 99.0 ± 7.50 days, or a range of 79 to 125 days. Yunot rope was far more durable than any of the other ropes used.

Its mean duration was 153.8 ± 12.2 days. The minimum duration was 133 days and the maximum, 192 days.

Breakage. Spiny bamboo rope broke the oftenest, a mean of 7.0 ± 0.20 times during the experiment. The range was from 6 to 9 times. Next was yunot rope which broke from 3 to 8 times, the mean being 5.2 ± 0.90 times. Coir rope broke a mean of 4.6 ± 1.40 times, the range being from 2 to 10 times. Abacá rope broke a mean of 3.5 ± 0.957 times, the range being from 2 to 6 times. Maguey rope broke a mean of 3.5 ± 1.04 times; one broke only once and the other, 6 times. Buri rope had a mean breaking incidence of 3.4 ± 0.509 times, the minimum being twice and the maximum 5 times. Danglin rope broke a mean of 2.4 ± 0.400 times, the range being from 1 to 3 times. Labayo rope broke a mean of 2.2 ± 0.379 times, the range being from 1 to 3 times.

Final weight. Spiny bamboo rope registered the lowest mean final weight of 198.0 ± 16.87 grams, the range being from 60 to 240 grams. Abacá rope was next with a mean weight of 214.2 ± 14.2 grams and a range of from 165 to 250 grams. Labayo, buri, and maguey ropes had approximately the same mean weights of 230.8 ± 14.65 grams, 232.8 ± 34.20 grams, and 233.8 ± 35.58 grams, respectively. The final weight of labayo rope ranged from 203 to 265 grams; of buri rope, from 160 to 323 grams; and of maguey rope, from 143 to 291 grams. The mean weight of danglin rope was 239.3 ± 23.35 grams; the lowest weight was 190 grams and the highest, 314 grams. Yunot rope had the highest mean weight of 247.4 ± 14.60 grams at the end of the investigation. The range was from 210 to 280 grams.

Final length. Abacá and spiny bamboo ropes were the shortest at the end of the investigation. Their mean final lengths were 381.6 ± 38.24 centimeters and 383.2 ± 28.72 centimeters, respectively. Abacá rope had a range of from 241 to 483 centimeters, and spiny bamboo rope, from 330 to 422 centimeters. Labayo and maguey ropes had about the same mean final lengths of 461.2 ± 20.32 centimeters and 463.8 ± 48.85 centimeters, respectively. The range in length of labayo rope was from 409 to 507 centimeters, and of maguey rope, from 371 to 572 centimeters. Danglin rope had a mean length of 468.5 ± 67.57 centimeters and a range of from 322 to 637 centimeters. Yunot rope had a mean length of 475.4 ± 19.673 centimeters, the range being from 426 to 543 centimeters. The mean length of coir rope was 504.5 ± 34.25 centimeters; the range was from 422 to 609 centimeters. The mean length of buri rope was 514.5 ± 44.59 centimeters at the end of the investigation. The shortest was 444 centimeters, and the longest 635 centimeters.

THE HORSES OF NORTH CENTRAL MINDANAO AND BUKIDNON [1]

VALENTE VILLEGAS

The majority of the 149 horses surveyed in Bukidnon and the cities of Ozamis, Iligan, and Cagayan de Oro were fair in conformation. The colors of the horses in the order of frequency were bay, buckskin, cream, and gray. The mean age was 6.9 ± 0.2 years. The mean height was 48.6 ± 0.2 inches (123.4 centimeters).

Nineteen and seven-tenths per cent of the horses had big heads; 3.7 per cent had long heads; 38.0 per cent were straight-faced; 31.4 per cent were Roman-nosed; and 18.3 per cent were dish-faced. Eleven and seven-tenths per cent had short necks. Thirty-one and four-tenths per cent were splay-footed; 5.8 per cent were pigeon-toed; and 32.1 per cent had flat feet. Eleven per cent had straight pasterns and 4.4 per cent had low pasterns. Sixty-two and eight-tenths per cent had drooping croups; 70.8 per cent were cow-hocked; and 77.4 per cent were sickle-hocked. Close to one-half of the horses showed marks of interfering.

From May 9 to 26, 1952, the qualities of the Philippine ponies found in north central Mindanao and Bukidnon were studied. Emphasis was placed on the color, age, height, and defects of the animals. In Ozamis City, Iligan City, and Cagayan de Oro City, the study was made on horses hitched to two-wheeled vehicles, called *tartanillas*, which are the principal means of conveyance in these cities. In the province of Bukidnon the study was made on saddle and breeding horses.

One hundred forty-nine horses were observed, of which 18 were in Ozamis City, 28 in Iligan City, 83 in Cagayan de Oro City, and 20 in Bukidnon province. Of these ponies, 89.9 per cent were males; 2.3 per cent were cryptorchids; and 3.5 per cent, castrated. Eight and one-tenth per cent were grades, one of which was castrated.

CONFORMATION

As a whole, the Philippine ponies in north central Mindanao and Bukidnon were of fair conformation, only 2.2 per cent being definitely ugly. Sixteen and eight-tenths per cent were beautiful, possessing style and good all-round conformation. Eight per cent were undersized. Seven and three-tenths per cent were big-boned, muscular, and strong; one horse had fine bones.

COLOR

The most common colors observed among the native horses were bay, buckskin, cream, and gray, in descending order. Bay was present in 30.1 per cent, buckskin in 18.1 per cent, cream in 16.5 per cent,

[1] General Contribution No. 866.

and gray in 15.0 per cent. Other colors observed were roan, black, chestnut, mouse, albino, and skewbald.

In earlier surveys bay, followed by gray, was the ranking color of horses in nine municipalities of Batangas and Laguna.[2, 3, 4, 5, 6, 7]

AGE

The mean age of the native horses was 6.9 ± 0.2 years. The youngest of those showing more or less definite age according to dentition was two years old, and the oldest was 12.5 years old. Four were sucklings and three were over 12.5 years old. Eighty-five and five-tenths per cent of the native horses were between four and ten years of age, most of them being six years old. In comparison, Lizaso found the average age of horses in Laguna to be 6.96 years; Mojares, in Lipa, 6.20 years; Caliñgasan, in Batangas, 5.85 years; Reduque, in Laguna, 6.81 ∓ 0.034 years; Banzon, in Laguna, 7.3 ∓ 0.1657 years; and Cangao, in Batangas, 6.09 ∓ 0.175 years.

HEIGHT

In this survey the mean height of all the horses was 48.6 ± 0.2 inches (123.4 centimeters). The range was from 44 to 53 inches (111.8 to 134.6 centimeters). Sixty-two and seven-tenths per cent of the native horses were between 47.5 and 50 inches (120.7 to 127.0 centimeters). Most of them were 49 inches (124.5 centimeters) tall. The grades were 51 to 54 inches (129.5 to 137.2 centimeters) in height, the average being 52 inches (132.1 centimeters).

In earlier surveys Lizaso found the average height of horses in Laguna to be 123.7 centimeters; Mojares, in Lipa City, 128.3 centimeters; Caliñgasan, in Batangas, 124.5 centimeters; Reduque, in Laguna, 122.0 ∓ 0.431 centimeters; Banzon, in Laguna, 121 ∓ 0.331 centimeters; and Cangao, in Batangas, 124.73 ∓ 0.34 centimeters.

DEFECTS

Head. Mackie[8] stated that the horses of Sulu and part of Mindanao belong to a distinct type. They possess heads that "are broad, with forehead inclined to be bumpy, ears rather long and set obliquely on the head; eyes large and far apart; profile straight, almost dished; muzzle square, with large nostrils." In this study, the writer noted that 19.7 per cent of the horses had big heads out of proportion to the size of their bodies; 3.7 per cent had long heads; 38.0 per cent were straight-faced; 31.4 per cent were Roman-nosed; and 18.3 per cent were dish-faced. One and five-tenths per cent were suffering

[2] J. Lizaso, *Philippine Agriculturist*, **10**, 135 (1921).
[3] U. A. Mojares, *Philippine Agriculturist*, **15**, 159 (1924).
[4] M. G. Caliñgasan, *Philippine Agriculturist*, **19**, 541 (1926).
[5] Jacinto M. Reduque, *The Philippine Jour. Animal Indus.*, (1) **11**, 35 (1950).
[6] Manuel G. Banzon, Jr., *Philippine Agriculturist*, **35**, 202 (1951).
[7] Floro P. Cangao, *The Philippine Jour. Animal Indus.*, (2–4) **11**, 115 (1950).
[8] David B. Mackie, *Jour. Heredity*, (8) 7, 373 (1916).

from *osteoporosis*. Many horses had large cuts at the mouth corners, apparently produced by the drivers' frequent jerking of the line to make the horses run faster.

Neck. Eleven and seven-tenths per cent of the horses had short necks. Only two horses were ewe-necked.

Forelimbs. Four horses had bowed knees. Nineteen and seven-tenths per cent had broken knees either because of weakness of the knees or overwork, or both. Three horses had windgall on the front fetlock joints, and one horse had a swollen left knee. Thirty-one and four-tenths per cent had splayfeet and 5.8 per cent were pigeon-toed. Eleven per cent had straight pasterns and 4.4 per cent had low pasterns. Three horses had clubfeet and 32.1 per cent had flat feet. Seven and three-tenths per cent of the horses had front feet that were too small for their size.

Body. Mackie believes that Philippine horses have well-developed chests and shoulders. The writer noted a similar constitutional vigor in three horses. One horse had a shallow chest, another a tucked-up belly, and a third a potbelly. Mackie added that the withers of Philippine horses are strong, though not prominent, and the bodies fairly long. In this survey two ponies had small bodies. Most of the horses had strong, straight backs. Only 2.2 per cent had sway-backs, and the same percentage had roach backs.

Hindquarters. Two horses had poorly developed hindquarters. Mackie reported that the croups of Philippine horses are sloping but not narrow; the writer found that 62.8 per cent of the horses surveyed had drooping croups and two horses had narrow croups. Mackie further noted that the hocks of the horses are well placed together and not cow-hocked. The writer recorded 70.8 per cent of the horses as cow-hocked and 77.4 per cent as sickle-hocked. Bandy legs, the opposite of cow-hock, was not observed. Mackie also described the legs as rather short and the hoofs as oval, well-formed, and hard. Five horses in this survey showed knuckling of the hind feet, and one horse had windgall on the hind fetlock joints. One mare had a knocked-down right hip and two horses had swollen right hocks.

Gait. Forty-six and seven-tenths per cent of the horses had marks of interfering, and 20.4 per cent, of forging. Three horses dragged their hind feet.

COLLEGE AND ALUMNI NOTES

The Indonesian Trade Mission to the Philippines, accompanied by Mr. Teofilo P. Sison of the Bureau of Commerce, visited the College on November 5, 1953. The Mission was composed of the following: Dr. R. A. Asmaun, chairman of the delegation, head of the Directorate, Foreign Economic Relations, Ministry of Economic Affairs, Ambassador Extraordinary and Plenipotentiary; Mr. F. Salim, member, head of Section of Trade and Industry Directorate, Economic and Judicial Affairs, Ministry of Foreign Affairs; Mr. A. D. Pattiradjawane, member, head of Planning Bureau, Central Import Office, Ministry of Economic Affairs; Mr. R. Soenardjo Atmodipoerwo, member, Ministry of Agriculture; Mr. M. Tabrani, advisor to the delegation and business representative; and Mr. R. Saroso Harsono, advisor to the delegation.

Mr. John Hepler, of the FOA, and Assistant Director Francisco Galang, '14, of the Bureau of Agricultural Extension, visited the College on October 21, 1953, and conferred with Professors Robinson and Sacay regarding the course in extension methods for prospective extension workers.

Messrs. Wallace J. Awgen and Fred Alfeneito, of the Caltex Refinery in Batangas, visited the campus recently to inquire about lawn grasses.

Mr. Kurt H. Ehlers and Mr. Martin Duarte, representatives of Koppel (Phil.), Inc., were campus visitors on October 22, 1953. They conferred with Dr. L. S. Robertson and Professor N. B. Tablante, of the Department of Agricultural Economics, and with Professor A. B. Catambay, of the Department of Agricultural Engineering, on the possibilities and prospects of mechanizing Philippine farms.

Other recent campus visitors were Mr. Harold E. Schwartz, of the FOA, Saigon, Vietnam, and Rev. Miguel Selga, S.J.

Dr. and Mrs. C. A. Bratton have resumed their duties at Cornell University, according to a letter received from them by the Dean. "The many courtesies extended to us and the spirit of cooperation and fellowship experienced during the past year will be cherished by us for years to come. The friendliness of the Los Bañôs people is a thing to be encouraged throughout the world," Doctor Bratton wrote.

The following are new members of the College staff: Mr. Prescillano M. Zamora, instructor in the Department of Agricultural Botany; Miss Paula A. G. Santos, research assistant in the Department of Soils; and Misses Epifania Cruz and Lolita Austria, research assistants in the Department of Animal Husbandry.

Former UP President B. M. Gonzalez, '13, accompanied by Mrs. Gonzalez and their children Lilia and Bienvenido, was a campus visitor on October 30, 1953.

Mr. Amado A. Santos, '31, is research sugar technologist of the Lopez Sugar Central in Fabrica, Negros Occidental. He was formerly manager and chemist of Santos and Baens Laboratories in Manila.

Mr. Nicanor C. Manipula, '34, is assistant horticulturist at the Manambulan Citrus Development Project in Davao City.

Mr. Ludovico I. Engle, '43, soil technologist in the Bureau of Soil Conservation, is in charge of soil fertility in Panay. He was formerly teacher of agriculture in the Iloilo National Agricultural School.

Mr. Porfirio C. Soliva, '45, is junior fertilizer supervisor, Fertilizer Administration, with station in Zamboanga del Norte.

Mr. Cornelio C. Magbanua, '46, is a practicing attorney in Cebu City.

Sister Veronica (Miss Luisa R. Mondoñedo, '46, *magna cum laude*) came to the College on October 21, 1953, to get ornamental plants for the St. Bridget's Academy in Batangas, Batangas, where she is a faculty member.

Mr. Leonardo Catral, '47, was a recent campus visitor. He is engaged in farming in Alcala, Cagayan.

Mr. Renato B. Jagunap, '50, is municipal agriculturist of the Bureau of Agricultural Extension in Leganes, Iloilo. He also operates a farm with the aid of a Farmall Cub tractor.

Vice-President and Mrs. Richard Nixon and party visited the College on November 23, 1953. The Vice-President gave a short talk to the members of the faculty and student body.

Dean K. A. Ryerson of the College of Agriculture of the University of California, head of the US delegation to the Eighth Pacific Science Congress and the Fourth Far-Eastern Prehistory Congress, visited the College and spoke at a special convocation on November 13, 1953.

Dr. L. D. Baver, director of the experiment station of the Hawaiian Sugar Planters' Association, was guest speaker at a special convocation on November 23, 1953.

Dr. Valente Villegas and Dr. John K. Loosli, of the Department of Animal Husbandry, in company with Mr. James A. Robinson, of the Foreign Operations Administration, and Dr. Mariano R. Montemayor, of the Bureau of Animal Industry, made a trip to central, northern, and western Luzon provinces from October 27 to November 1, 1953. They observed the different livestock projects of various government agencies.

The staff of the National Media Production Center, headed by its director, Mr. Z. Nuguid, Jr., visited the campus on November 8, 1953. "We found the trip highly instructive and I am sure it will help us in the preparation of information materials for your project," Mr. Nuguid wrote.

A scientific meeting of the Los Baños Biological Club was held on October 30, 1953. The following papers were read and discussed: (1) "On the stability of one-inch apitong wood under atmospheric condition when boiled in water for different lengths of time," by Messrs. Domingo Lantican and Mario A. Eusebio; and (2) "Some statistical aspects of the use of composites for sampling soil," by Prof. Burton T. Oñate.

The students of the Vocational Division of Luis Palad Rural High School, Tayabas, Quezon, visited the Department of Animal Husbandry on October 17, 1953. They were accompanied by the vocational teachers headed by Mr. Daniel Riola, the principal of the school. Mr. Riola was a member of the Summer Poultry Class in this College in 1937.

Mr. Victoriano J. Madrid, '34, of the Bureau of Plant Industry, recently returned from the United States. He is one of the FOA-PHILCUSA trainees.

Mr. Ceferino R. Fernandez, '36, is the provincial agriculturist of the Bureau of Agricultural Extension in Masbate.

Mr. Eduardo S. Paje, '43, is acting provincial fertilizer supervisor in Albay. He was formerly teaching agriculture at Roxas Memorial Agricultural School in Guinobatan.

Mr. Cecilio M. Paras, '45, is junior fertilizer supervisor in Irosin, Sorsogon.

Messrs. Hector A. Rivera, '36, Domingo Tapayan, '41, and Leon Mencias, '37, who are at present connected with the Central Bank, visited the College on November 12, 1953, and conferred with the staff of the Department of Agricultural Economics regarding possible problems of research in rural banking. A week before, Messrs. Rivera and Tapayan were on the campus, together with Mr. R. Marino Corpus, director of the Loan and Credit Division, Central Bank of the Philippines.

Mr. Roland N. Caasi, '52, is teaching at the Bayambang High School in Pangasinan.

Mr. Eleuterio H. Aguas, '50, heads the team of field supervisors of the ACCFA in the province of Pampanga.

Dr. Amando M. Dalisay, '37, executive secretary of the PHILCUSA and concurrently undersecretary of the Department of Agriculture and Natural Resources, was guest speaker at a convocation held under the auspices of the Agricultural Economics Club on December 4, 1953. He spoke on the role of the social sciences in the economic development of the country. Orlando J. Sacay is the president of the club and Prof. Nathaniel B. Tablante, the adviser.

On December 5, 1953, Doctor Dalisay was guest of honor and speaker at a fellowship luncheon of the local YMCA. He was also the guest of honor at the Twelfth Forestry Day of the College of Forestry on November 29, 1953.

Director Harry A. Brenn, of the FOA, wrote the Dean thanking him and the members of the faculty for the preparation made in connection with the visit of Vice-President and Mrs. Nixon on November 23, 1953. "All were favorably impressed with the expeditious way in which the party was conducted while on the campus; with the ROTC unit that served as an honor guard; with the brief but effective way in which you introduced the Vice-President to the students; and also with the splendid display of tropical products that were prepared for the occasion. Please express to Dr. Leon Gonzalez our appreciation for the work that he did in arranging the display of tropical products, and to all others who assisted you on this occasion," he stated.

Drs. N. C. Brady and N. L. Galvez, of the Department of Soils, and Drs. P. Work and L. G. Gonzalez, of the Department of Agronomy, joined Drs. J. Thorp and H. S. Gibbs, both known pedalogists, in their field trip to Central Luzon and Mountain Province. This trip was suggested by the Soil Resources Division of the Eighth Pacific Science Congress. Messrs. A. Barrera, '25, and I. Romero, '41, of the Bureau of Soil Conservation, were also in the party.

The local branch of the YMCA celebrated on December 5, 1953, the forty-second anniversary of the founding of the YMCA in the Philippines. The celebration included an open house, athletic contests in the afternoon, and an anniversary dance in the evening. Dr. F. O. Santos is the chairman of the Committee of Management and Mr. Tito Mercado, the secretary.

Delegates to the Eighth Pacific Science Congress and the Fourth Far-Eastern Prehistory Congress, numbering about 450, visited the College on November 26, 1953. They were served luncheon at the Home Technology Building.

Biology students of the National Teachers' College (Malabon, Rizal branch) visited the campus on November 21, 1953. Mr. F. Francia, of the Department of Agricultural Botany, gave a lecture on classification of plants. Prof. N. B. Tablante showed the visitors around.

The senior class organization of the University Rural High School held a costume party on November 28, 1953. Melanio Domdom is the president and Mr. Martin V. Jarmin, the adviser of the organization.

Dr. Cesar A. Villariba, '48, was a recent campus visitor. He recently returned from Columbia University where he obtained the degree of Doctor of Education. He is now connected with the Luzonian Colleges in Lucena, Quezon.

Dr. Apolinario A. Carañgal, Jr., '48, returned from the United States after completing his doctorate in chemistry at the Ohio State University. He is at present on the staff of the Department of Agricultural Chemistry of the College.

Mr. Victoriano A. Gaborno, '42, arrived from the United States where he stayed for more than a year pursuing studies at the Louisiana State University as a FOA-PHILCUSA trainee. He also visited other institutions during his stay there. He was a recent campus visitor.

Mr. Pio C. Catalon, Jr., '50, is the fertilizer supervisor of Ozamis City.

Mr. Marcos de la Cruz, '49, is assistant soil technologist in the Bureau of Soil Conservation.

Mr. Demetrio M. Cabantac, '50, is teaching at the Upi Agricultural High School in Upi, Cotabato. He is in charge of livestock projects of the school.

Mr. Leonardo A. Abarra, '52, is junior fertilizer supervisor in Ilagan, Isabela. He was formerly teaching at St. Ferdinand College in Ilagan.

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SWORN STATEMENT

(Required by Act No. 2580)

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(Sgd.) J. M. CAPINPIN
Business Manager

Subscribed and sworn to before me this 24th day of September, 1954, at Los Baños, Laguna, the affiant exhibiting his Residence Certificate No. A-4147103 issued at Los Baños, Laguna, on January 2, 1954.

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(Sgd.) ISIDRO P. GUICO
Notary Public
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